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TITLE: LIQUID CRYSTAL COMPOUND WITH NEGATIVE PERMITTIVITY ANISOTROPY VALUE, LIQUID CRYSTAL COMPOSITION CONTAINING THE LIQUID CRYSTAL COMPOUND, AND LIQUID CRYSTAL DISPLAY ELEMENT USING THE LIQUID CRYSTAL COMPO

PUBN-DATE: February 2, 1999

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INT-CL (IPC): C07 F 7/08; C07 F 7/12; C09 K 19/40; C09 K 19/42; G02 F 1/13

ABSTRACT:

PROBLEM TO BE SOLVED: To obtain the subject new compound capable of being applied to preparation of a liquid crystal composition for various kinds of display systems, including a vertical orientation system, etc., using a compound or composition having a permittivity anisotropy value being not only negative but also positive.

SOLUTION: This compound is a liquid crystal one of formula I [R1 and Y are an 1-30C straight chain or branched chain alkyl or the like.; rings A1 to A5 are separately a silacyclohexane ring, a ring of formula II (W1 and W2 are separately F or Cl) or the like; X1 to X4 are separately a single bond, an 1-4C alkylene; R2 and R3 are each H, halogen or the like; a1 to a5 are separately 0 or 1], e.g. a compound of formula III. A compound of formula I is obtained e.g. through the processes of a formation of the ring of formula II, formation of a silacyclohexane ring, introduction of a difluoromethyleneoxy, etc. According to this, there provides a liquid crystal compound having a low viscosity and negative permittivity anisotropy value whose absolute value is large, having a controlled optical anisotropy value and high specific resistance, etc., and stable against heat and ultraviolet irradiation.

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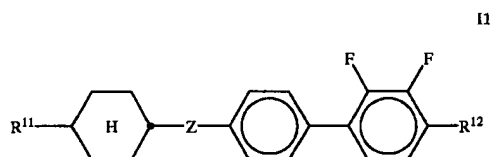
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(19) **United States**(12) **Patent Application Publication**
Klasen et al.(10) **Pub. No.: US 2002/0014613 A1**(43) **Pub. Date: Feb. 7, 2002**(54) **LIQUID-CRYSTALLINE MEDIUM**(75) **Inventors:** Melanie Klasen, Heuchelheim (DE);
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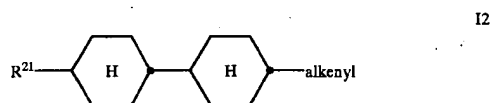
Apr. 14, 2000 (DE)..... 100 18 899.0

Publication Classification(51) **Int. Cl.⁷** C09K 19/30; C09K 19/12(52) **U.S. Cl.** 252/299.63; 428/1.1; 252/299.66(57) **ABSTRACT**

The invention relates to a liquid-crystalline medium based on a mixture of polar compounds of negative dielectric anisotropy which comprises at least one compound of the formula I1



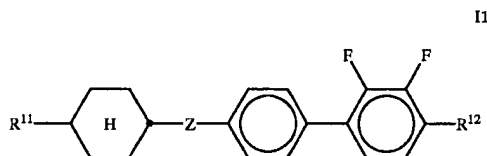
and at least one compound of the formula I2

in which R¹¹, R¹², R²¹ and Z are as defined in claim 1, and the use thereof for an active matrix display based on the ECB or IPS effect.

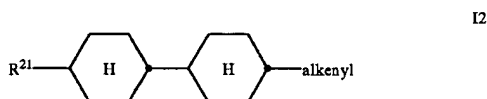
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LIQUID-CRYSTALLINE MEDIUM

[0001] The invention relates to a liquid-crystalline medium based on a mixture of polar compounds having negative dielectric anisotropy, which comprises at least one compound of the formula I1



[0002] and at least one compound of the formula I2



[0003] in which

[0004] R^{11} , R^{12} and R^{21} are each, independently of one another, an alkyl or alkenyl radical having up to 15 carbon atoms which is unsubstituted, monosubstituted by CN or CF_3 or at least monosubstituted by halogen, where one or more CH_2 groups in these radicals may also, in each case independently of one another, be replaced by $-O-$, $-S-$,



[0005] $-C=C-$, $-CO-$, $-CO-O-$, $-O-CO-$ or $-O-CO-O-$ in such a way that O atoms are not linked directly to one another,

[0006] Z is $-C_2H_4-$, $-CH=CH-$, $-CF_2O-$, $-OCF_2-$ or a single bond, and

[0007] alkenyl is a straight-chain alkenyl radical having 2-6 carbon atoms.

[0008] Such media are particularly suitable for electro-optical displays with active matrix addressing based on the ECB effect, and for IPS (in-plane switching) displays.

[0009] The principle of electrically controlled birefringence, the ECB effect or alternatively DAP effect (deformation of aligned phases), was described for the first time in 1971 (M. F. Schieckel and K. Fahrnschon, "Deformation of nematic liquid crystals with vertical orientation in electrical fields", Appl. Phys. Lett. 19 (1971), 3912). This was followed by papers by J. F. Kahn (Appl. Phys. Lett. 20 (1972), 1193) and G. Labrunie and J. Robert (J. Appl. Phys. 44 (1973), 4869).

[0010] The papers by J. Robert and F. Clerc (SID 80 Digest Techn. Papers (1980), 30), J. Duchene (Displays 7

(1986), 3) and H. Schad (SID 82 Digest Techn. Papers (1982), 244) have shown that liquid-crystalline phases must have high values for the ratio between the elastic constants K_3/K_1 , high values for the optical anisotropy Δn and values for the dielectric anisotropy $\Delta\epsilon$ of from -0.5 to -5 in order to be suitable for high-information display elements based on the ECB effect. Electro-optical display elements based on the ECB effect have a homeotropic edge alignment. Dielectrically negative liquid-crystal media can also be used in displays utilizing the so-called IPS effect.

[0011] Technical use of this effect in electro-optical display elements requires LC phases which must satisfy a multiplicity of requirements. Particularly important here are chemical resistance to moisture, air and physical effects, such as heat, radiation in the infrared, visible and ultraviolet regions and direct and alternating electric fields.

[0012] Technically suitable LC phases are furthermore required to have a liquid-crystalline mesophase in a suitable temperature range and low viscosity.

[0013] None of the series of compounds having a liquid-crystalline mesophase which have been disclosed hitherto includes a single compound which meets all these requirements. In general, therefore, mixtures of from 2 to 25, preferably from 3 to 18, compounds are prepared in order to obtain substances which can be used as LC phases. However, optimum phases could not be prepared easily in this way, since no liquid-crystalline materials of significantly negative dielectric anisotropy were hitherto available.

[0014] Matrix liquid-crystal displays are known. Non-linear elements which can be used for individual switching of the individual pixels are, for example, active elements (i.e. transistors). This is then referred to as an "active matrix", and a distinction can be made between two types:

[0015] 1. MOS (metal oxide semiconductor) transistors on a silicon wafer as substrate.

[0016] 2. Thin-film transistors (TFTs) on a glass plate as substrate.

[0017] In the case of type 1, the electro-optical effect used is usually dynamic scattering or the guest-host effect. The use of single-crystal silicon as the substrate material limits the display size, since even modular assembly of various part-displays results in problems at the joints.

[0018] In the case of more promising type 2, which is preferred, the electro-optical effect used is usually the TN effect.

[0019] A distinction is made between two technologies: TFTs comprising compound semiconductors, for example CdSe, or TFTs based on polycrystalline or amorphous silicon. Intensive work is being carried out worldwide on the latter technology.

[0020] The TFT matrix is applied to the inside of one glass plate of the display, while the other glass plate carries the transparent counterelectrode on its inside. Compared with the size of the pixel electrode, the TFT is very small and has virtually no adverse effect on the image. This technology can also be expanded to fully colour-compatible displays, in which a mosaic of red, green and blue filters is arranged in such a way that each filter element is located opposite a switchable pixel.

[0021] The TFT displays usually operate as TN cells with crossed polarizers in transmission and are backlit.

[0022] The term MLC displays here covers any matrix display containing integrated non-linear elements, i.e., besides the active matrix, also displays containing passive elements, such as varistors or diodes (MIM=metal-insulator-metal).

[0023] MLC displays of this type are particularly suitable for TV applications (for example pocket TVs) or for high-information displays in automobile or aircraft construction. Besides problems regarding the angle dependence of the contrast and the response times, difficulties also arise in MLC displays due to inadequate resistivity of the liquid-crystal mixtures [TOGASHI, S., SEKIGUCHI, K., TANABE, H., YAMAMOTO, E., SORIMACHI, K., TAJIMA, E., WATANABE, H., SHIMIZU, H., Proc. Eurodisplay 84, Sept. 1984: A 210-288 Matrix LCD Controlled by Double Stage Diode Rings, p. 141 ff, Paris; STROMER, M., Proc. Eurodisplay 84, September 1984: Design of Thin Film Transistors for Matrix Addressing of Television Liquid Crystal Displays, p. 145 ff, Paris]. With decreasing resistance, the contrast of an MLC display drops. Since the resistivity of the liquid-crystal mixture generally drops over the life of an MLC display owing to interaction with the interior surfaces of the display, a high (initial) resistance is very important for displays which must have acceptable resistance values over a long service life.

[0024] The disadvantage of the MLC-TN displays disclosed hitherto is due to their comparatively low contrast, relatively high viewing-angle dependence and the difficulty of generating grey shades in these displays.

[0025] EP 0 474 062 discloses MLC displays based on the ECB effect. However, the LC mixtures described therein, which are based on 2,3-difluorophenyl derivatives containing an ester, ether or ethyl bridge, have low "voltage holding ratio" (HR) values after UV exposure.

[0026] There thus continues to be a great demand for MLC displays which have very high resistivity at the same time as a broad operating temperature range, short response times and a low threshold voltage which can be used to produce various grey shades.

[0027] It is an object of the invention to provide MLC displays based on the ECB effect which do not have the abovementioned disadvantages, or only do so to a lesser extent, and at the same time have very high resistivities.

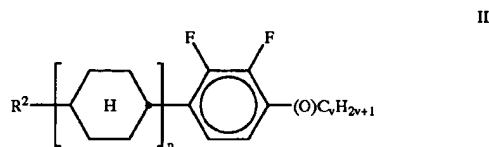
[0028] It has now been found that this object can be achieved if nematic liquid-crystal mixtures comprising at least one compound of the formula I1 and one compound of the formula I2 are used in these display elements.

[0029] The invention thus relates to a liquid-crystalline medium based on a mixture of polar compounds having negative dielectric anisotropy which comprises at least one compound of the formula I1 and at least one compound of the formula I2.

[0030] The mixture according to the invention has very favorable values for the capacitive threshold, relatively high values for the holding ratio and at the same time very good low-temperature stability.

[0031] Some preferred embodiments are mentioned below:

[0032] a) A medium which additionally comprises one or more compounds of the formula II:



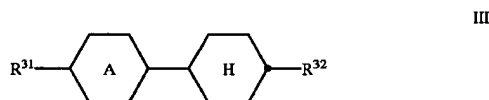
[0033] in which

[0034] R^2 is independently as defined for R^{11} , R^{12} and R^{21} ,

[0035] p is 1 or 2, and

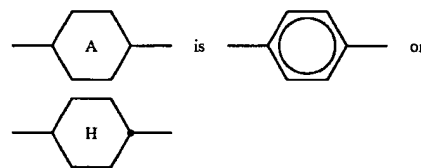
[0036] v is from 1 to 6.

[0037] b) A medium which additionally comprises one or more compounds of the formula III:



[0038] in which

[0039] R^{31} and R^{32} are each, independently of one another, a straight-chain alkyl or alkyloxy radical having up to 12 carbon atoms, and



[0040] c) A medium which comprises two, three, four or more, preferably two, three or four, compounds of the formula I1.

[0041] d) A medium which comprises at least two compounds of the formula I2.

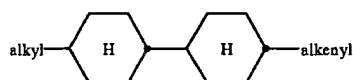
[0042] e) A medium in which the proportion of compounds of the formula I1 in the total mixture is at least 10% by weight, preferably at least 20% by weight.

[0043] f) A medium in which the proportion of compounds of the formula I2 in the total mixture is at least 5% by weight, preferably at least 10% by weight.

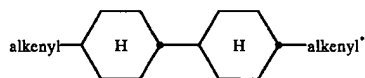
[0044] g) A medium in which the proportion of compounds of the formula II in the total mixture is at least 20% by weight.

[0045] h) A medium in which the proportion of compounds of the formula III in the total mixture is at least 5% by weight.

[0046] i) A medium which comprises at least one compound selected from the formulae I2a and I2b.

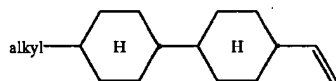


I2a

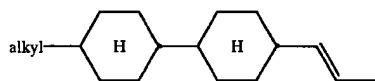


I2b

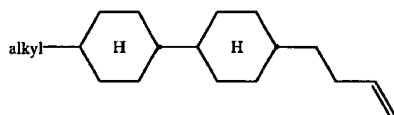
[0047] Particular preference is given to the compounds of the formulae I2aa-I2ad and I2ba-I2bc:



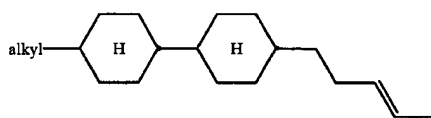
I2aa



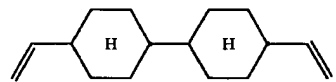
I2ab



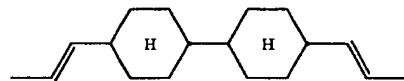
I2ac



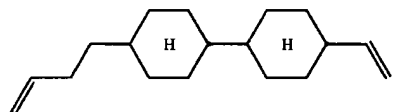
I2ad



I2ba

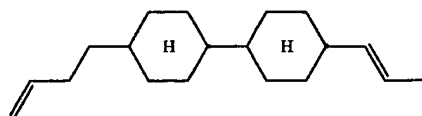


I2bb

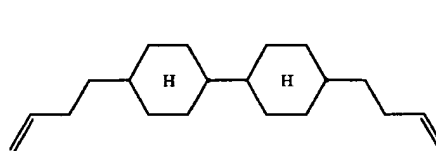


I2bc

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I2bd



I2be

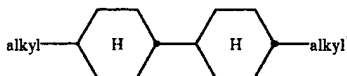
[0048] in which

[0049] alkenyl and

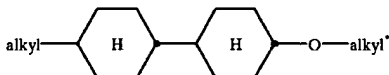
[0050] alkenyl* are each, independently of one another, a straight-chain alkenyl radical having 2-6 carbon atoms, and

[0051] alkyl is a straight-chain alkyl radical having 1-6 carbon atoms.

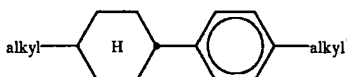
[0052] j) A medium which additionally comprises a compound selected from the formulae IIIa to IIId:



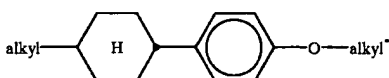
IIIa



IIIb



IIIc



IIId

[0053] in which

[0054] alkyl and

[0055] alkyl* are each, independently of one another, a straight-chain alkyl radical having 1-6 carbon atoms.

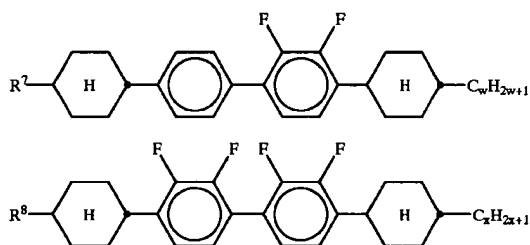
[0056] The medium according to the invention preferably comprises at least one compound of the formula IIIa and/or formula IIIb.

[0057] k) A medium which essentially consists of: 10-40% by weight of one or more compounds of the formula I1,

[0058] 5-30% by weight of one or more compounds of the formula I2, and

[0059] 20-70% by weight of one or more compounds of the formula II.

[0060] 1) A medium which additionally comprises one more compounds of the formulae

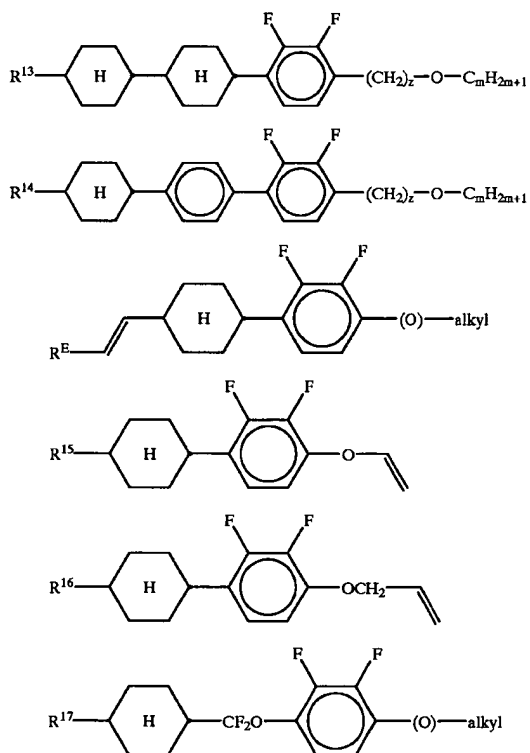


[0061] in which

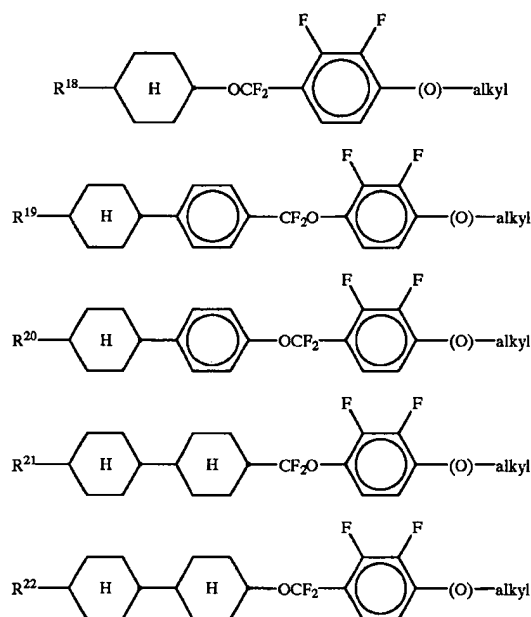
[0062] R^7 and R^8 are each, independently of one another, as defined for R^{11} , R^{12} and R^{21} in claim 1, and

[0063] w and x are each, independently of one another, from 1 to 6.

[0064] m) A medium which additionally comprises one more compounds of the formulae

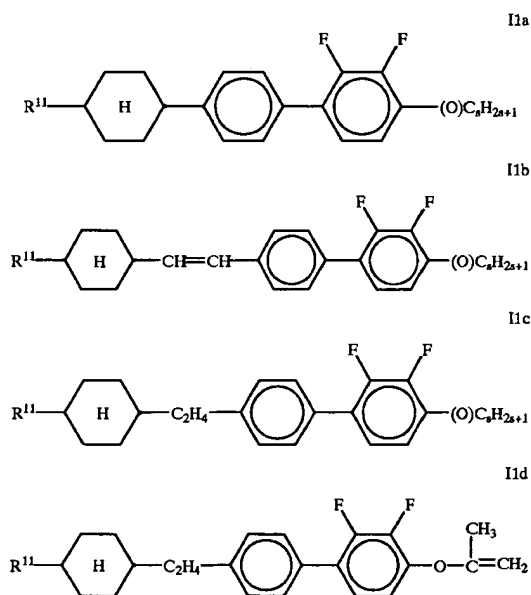


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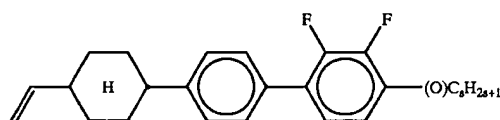
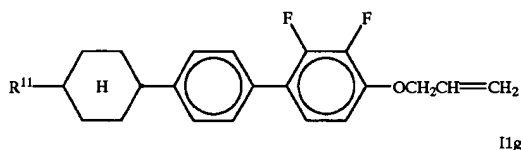
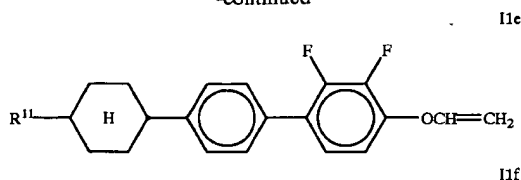


[0065] in which R^{13} - R^{22} are each, independently of one another, as defined for R^{11} , R^{12} and R^{21} , and z and m are each, independently of one another, 1-6. R^E is H, CH_3 , C_2H_5 or $n-C_3H_7$.

[0066] n) A medium in which the compound of the formula I1 is selected from the group consisting of I1a to I1g:



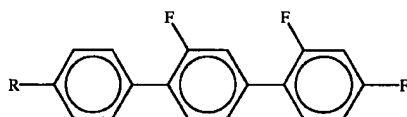
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[0067] in which R¹¹ is as defined above, and s is 1-12. R¹¹ is preferably straight-chain alkyl having 1 to 6 carbon atoms, vinyl, 1E-alkenyl or 3E-alkenyl.

[0068] o) A medium which comprises one or more compounds of the formula Ia and/or IIg.

[0069] p) A medium which additionally comprises one or more compounds of the formula



[0070] in which R is alkyl, alkenyl, alkoxy or alkenyloxy each having 1 or 2 to 6 carbon atoms.

[0071] The invention furthermore relates to an electro-optical display having active matrix addressing based on the ECB effect, characterized in that it comprises, as dielectric, a liquid-crystalline medium as defined above.

[0072] The liquid-crystal mixture preferably has a nematic phase range of at least 60 K and a maximum flow viscosity V_{20} of 30 mm².s⁻¹ at 20° C.

[0073] The liquid-crystal mixture according to the invention preferably has a $\Delta\epsilon$ of from about -0.5 to -6.0 , in particular from about -3.0 to -4.5 , where $\Delta\epsilon$ is the dielectric anisotropy. The rotational viscosity γ_1 is preferably <225 mPa.s, in particular <180 mPa.s.

[0074] The birefringence Δn in the liquid-crystal mixture is generally between 0.04 and 0.13, preferably between 0.06 and 0.11, and/or the dielectric constant $\epsilon_{||}$ of greater than or equal to 3, preferably from 3.2 to 8.5.

[0075] The dielectrics may also comprise further additives which are known to the person skilled in the art and are described in the literature.

[0076] For example, 0-15% of pleochroic dyes can be added, furthermore conductive salts, preferably ethyldim-

ethyl-dodecylammonium 4-hexoxybenzoate, tetrabutylammonium tetraphenylborate or complex salts of crown ethers (cf., for example, Haller et al., *Mol. Cryst. Liq. Cryst.*, Volume 24, pages 249-258 (1973)) for improving the conductivity, or substances for modifying the dielectric anisotropy, the viscosity and/or the alignment of the nematic phases. Such substances are described, for example, in DE-A 22 09 127, 22 40 864, 23 21 632, 23 38 281, 24 50 088, 26 37 430 and 28 53 728.

[0077] The individual components of the formulae I1, I2, II and III in the liquid-crystal phases according to the invention are either known or their modes of preparation can easily be derived from the prior art by the person skilled in the relevant art, since they are based on standard methods which are described in the literature.

[0078] The nematic liquid-crystal mixtures in the displays according to the invention generally comprise two components A and B, which themselves consist of one or more individual compounds.

[0079] Component A has significantly negative dielectric anisotropy and gives the nematic phase a dielectric anisotropy of ≤ -0.3 . It preferably comprises compounds of the formulae I1 and II.

[0080] The proportion of component A is preferably between 45 and 100%, in particular between 60 and 100%.

[0081] For component A, one (or more) individual compound(s) having a $\Delta\epsilon \leq -0.8$ are preferably selected. The smaller the proportion of component A in the total mixture, the more negative this value must be.

[0082] Component B has pronounced nematogenicity and a flow viscosity of not more than $30 \text{ mm}^2 \cdot \text{s}^{-1}$, preferably not more than $25 \text{ mm}^2 \cdot \text{s}^{-1}$, at 20°C . It preferably comprises compounds of the formulae I2 and III.

[0083] Particularly preferred individual compounds of component B are extremely low-viscosity nematic liquid crystals having a flow viscosity of not more than $18 \text{ m}^2 \cdot \text{s}^{-1}$, preferably not more than $12 \text{ mm}^2 \cdot \text{s}^{-1}$, at 20°C .

[0084] Component B has monotropic or enantiotropic nematogenicity, has no smectic phases and can prevent the occurrence of smectic phases in liquid-crystal mixtures down to very low temperatures. If, for example, a smectic liquid-crystal mixture is mixed with various materials of high nematogenicity, the degree of suppression of smectic phases that is achieved can be used to compare the nematogenicity of these materials.

[0085] Numerous suitable materials are known to the person skilled in the art from the literature. Particular preference is given to compounds of the formula III.

[0086] In addition, these liquid-crystal phases can also contain more than 18 components, preferably from 18 to 25 components.

[0087] The phases preferably contain from 4 to 15, in particular 5 to 12, compounds of the formulae I1, I2, II and optionally III.

[0088] Besides compounds of the formulae I1, I2, II and III, it is also possible for other constituents to be present, for

example in an amount of up to 45% of the total mixture, but preferably up to 35%, in particular up to 10%.

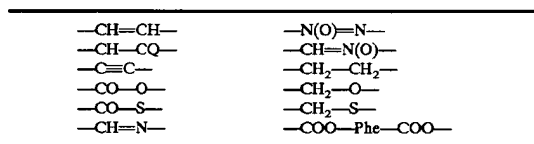
[0089] The other constituents are preferably selected from nematic or nematogenic substances, in particular known substances, from the classes consisting of the azoxy-benzenes, benzylideneanilines, biphenyls, terphenyls, phenyl or cyclohexyl benzoates, phenyl or cyclohexyl cyclohexanecarboxylates, phenylcyclohexanes, cyclohexyl-biphenyls, cyclohexylcyclohexanes, cyclohexyl-naphthalenes, 1, 4-bis-cyclohexylbiphenyls or cyclohexyl-pyrimidines, phenyl- or cyclohexyldioxanes, optionally halogenated stilbenes, benzyl phenyl ethers, tolans and substituted cinnamic acids.

[0090] Important compounds which can be used as constituents of liquid-crystal mixtures of this type can be characterized by the formula IV



IV

[0091] in which L and E are each a carbocyclic or heterocyclic ring system from the group consisting of 1,4-disubstituted benzene and cyclohexane rings, 4,4'-disubstituted biphenyl, phenylcyclohexane and cyclohexylcyclohexane systems, 2,5-disubstituted pyrimidine and 1,3-dioxane rings, 2,6-disubstituted naphthalene, di- and tetrahydronaphthalene, quinazoline and tetra-hydroquinazoline, G is



[0092] or a C—C single bond, Q is halogen, preferably chlorine, or —CN, and R⁹ and R¹⁰ are each alkyl, alkenyl, alkoxy, alkanoyloxy or alkoxycarbonyloxy having up to 18, preferably up to 8, carbon atoms, or one of these radicals is alternatively CN, NC, NO₂, NCS, CF₃, F, Cl or Br.

[0093] In most of these compounds, R⁹ and R¹⁰ are different from one another, one of these radicals usually being an alkyl or alkoxy group. However, other variants of the proposed substituents are also common. Many such substances or mixtures thereof are commercially available. All these substances can be prepared by methods which are known from the literature.

[0094] It will be appreciated by a person skilled in the art that the ECB mixture according to the invention may also comprise compounds in which, for example, H, N, O, Cl or F have been replaced by the corresponding isotopes.

[0095] The construction of the liquid-crystal displays according to the invention corresponds to the conventional geometry, as described, for example, in EP-A 0 240 379.

[0096] Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The following preferred specific embodiments are, therefore, to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever.

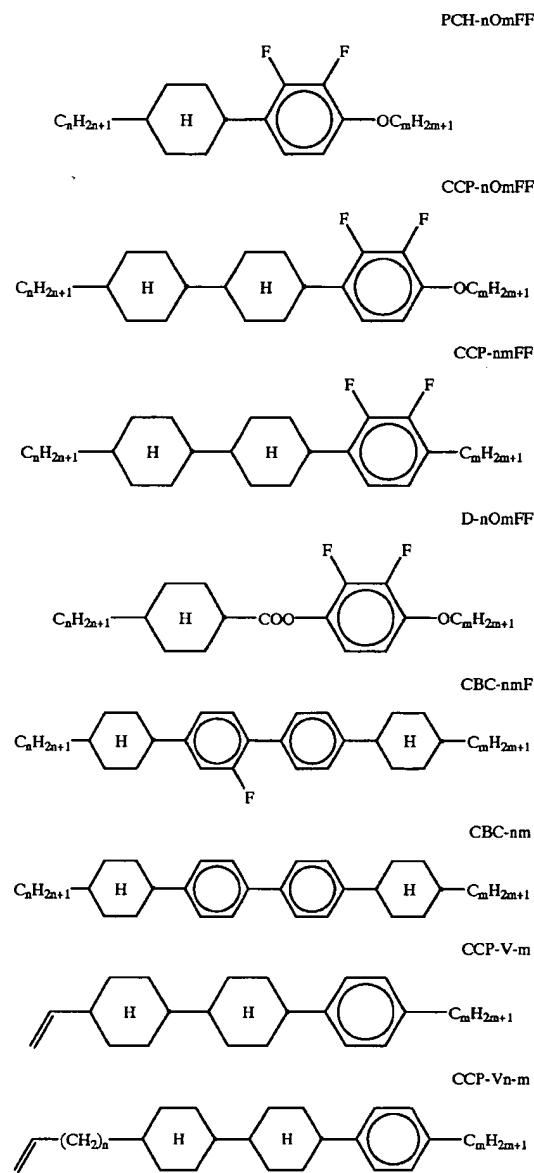
[0097] In the foregoing and in the following examples, all temperatures are set forth uncorrected in degrees Celsius; and, unless otherwise indicated, all parts and percentages are by weight.

[0098] The entire disclosure of all applications, patents and publications, cited above, and of corresponding German application No. DE 100 18 899.0, filed Apr. 14, 2000, is hereby incorporated by reference.

[0099] Besides the compounds of the formulae I1 and I2, the liquid-crystal mixtures according to the invention preferably comprise one or more of the compounds mentioned below.

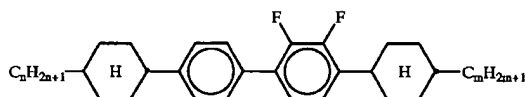
[0100] The following abbreviations are used:

[0101] (n, m=1-6; z=1-6)

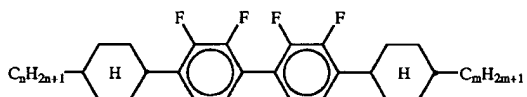


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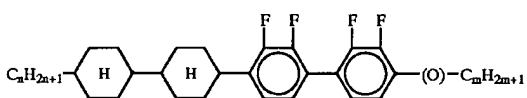
CPYC-n-m



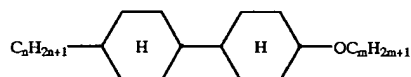
CYVC-n-m



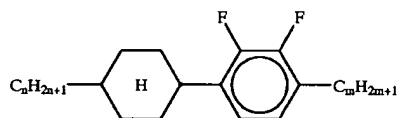
CCYY-n-(O)m



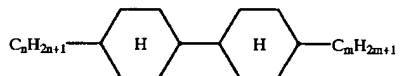
CCH-nOm



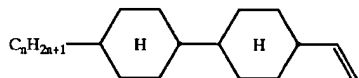
CY-n-m



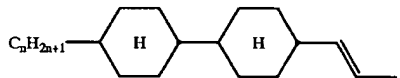
CCH-nm



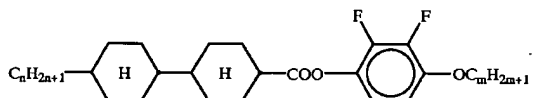
CC-n-V



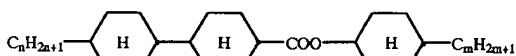
CC-n-V1



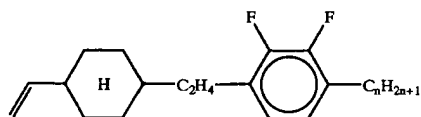
CP-nOmFF



CH-nm

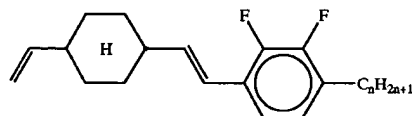


CEY-V-n

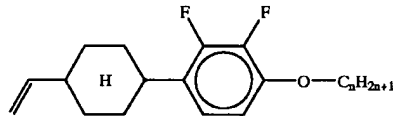


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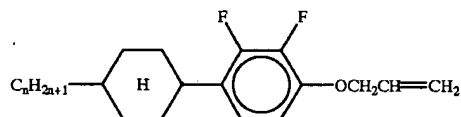
CVY-V-n



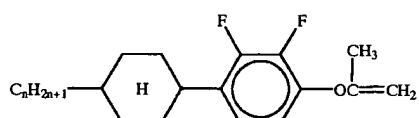
CY-V-On



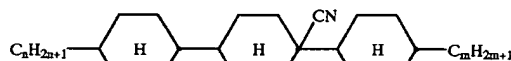
CY-n-O1V



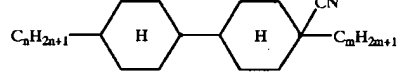
CY-n-OC(CH3)=CH2



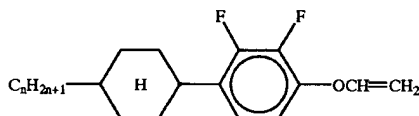
BCN-nm



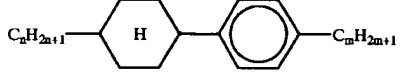
CCN-nm



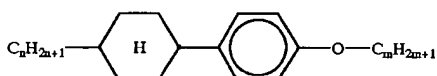
CY-n-OV



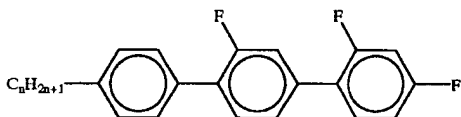
PCH-nm



PCH-nOm



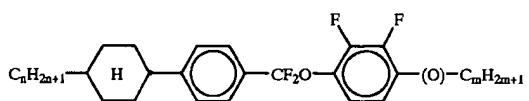
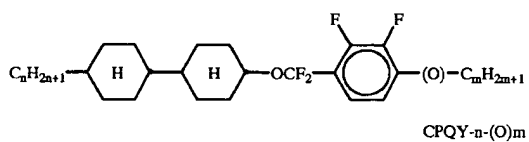
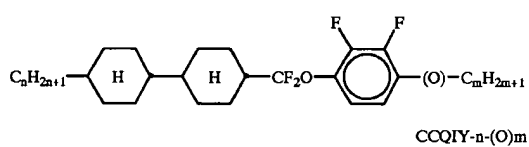
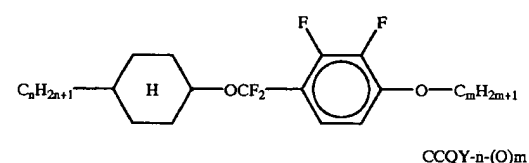
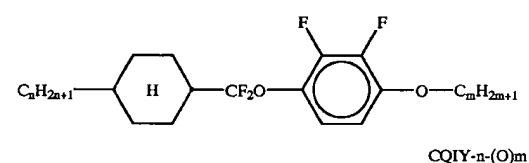
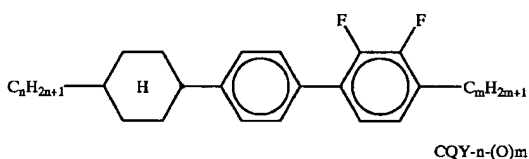
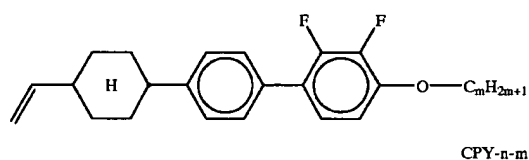
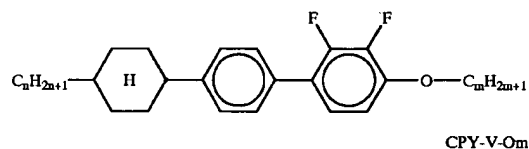
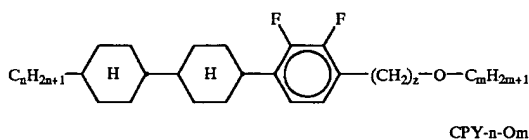
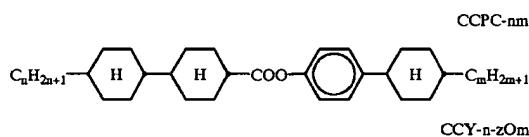
PGIGI-n-F



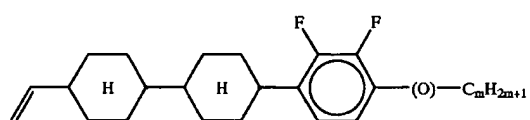
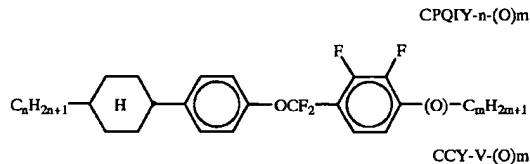
BCH-nm



-continued



-continued



[0102] The abbreviations furthermore have the following meanings:

[0103] V.threshold voltage, capacitive [V] at 20° C.

[0104] Δn optical anisotropy measured at 20° C. and 589 nm

[0105] Δε dielectric anisotropy at 20° C. and 1 kHz
c.p. clearing point [° C.]

[0106] γ₁ rotational viscosity measured at 20° C.
[mPa.s]

[0107] LTS low temperature stability

[0108] The display used to measure the threshold voltage has two plane-parallel outer plates at a separation of 5 μm and electrode layers covered by lecithin alignment layers on the inside of the outer plates, which produce a homeotropic alignment of the liquid crystal molecules.

MIXTURE EXAMPLES

Example 1

[0109]

PCH-304FF	18.0%	S → N:	<-40° C.
PCH-504FF	19.0%	Clearing point [° C.]:	69.5
BCH-32	8.0%	Δn [589 nm, 20° C.]:	+0.1011
CCP-V-1	7.0%	Δε [1 kHz, 20° C.]:	-3.3
CC-3-V1	8.0%	ε [1 kHz, 20° C.]:	3.6
CC-5-V	18.0%	γ ₁ [mPa · s, 20° C.]:	115
CPY-2-02	12.0%	V ₀ [V]:	2.10
CPY-3-02	10.0%	LTS in cells:	nem. > 1 000 h
		At -20° C., -30° C., -40° C.	

Example 2

[0110]

PCH-304FF	19.0%	S → N:	<-40° C.
PCH-504FF	20.0%	Clearing point [° C.]:	71.0
CCP-302FF	6.0%	Δn [589 nm, 20° C.]:	+0.1020
BCH-32	7.0%	Δε [1 kHz, 20° C.]:	-3.9
CCH-35	5.0%	ε [1 kHz, 20° C.]:	3.7
CC-3-V1	8.0%	γ ₁ [mPa · s, 20° C.]:	142

-continued

CC-5-V	11.0%	V_o [V]:	1.92
CPY-2-02	12.0%	LTS in cells:	nem. > 1 000 h
CPY-3-02	12.0%	At -20°C ., and -30°C .	

Example 3

[0111]

PCH-304FF	10.0%	$S \rightarrow N$:	$<-30^\circ\text{C}$.
PCH-502FF	8.0%	Clearing point [$^\circ\text{C}$.]:	75.5
PCH-504FF	18.0%	Δn [589 nm, 20°C .]:	+0.1005
CCP-302FF	10.0%	$\Delta\epsilon$ [1 kHz, 20°C .]:	-4.2
CC-3-V1	8.0%	$\epsilon_{ }$ [1 kHz, 20°C .]:	3.7
CC-5-V	13.0%	γ_1 [mPa \cdot s, 20°C .]:	149
CCH-35	5.0%	V_o [V]:	1.95
CPY-2-02	12.0%		
CPY-3-02	12.0%		
BCH-32	4.0%		

Example 4

[0112]

PCH-304FF	8.0%	$S \rightarrow N$:	$<-30^\circ\text{C}$.
PCH-502FF	8.0%	Clearing point [$^\circ\text{C}$.]:	83.5
PCH-504FF	18.0%	Δn [589 nm, 20°C .]:	+0.1022
CCP-302FF	14.0%	$\Delta\epsilon$ [1 kHz, 20°C .]:	-4.9
CCP-31FF	7.0%	$\epsilon_{ }$ [1 kHz, 20°C .]:	3.8
CC-5-V	8.0%	γ_1 [mPa \cdot s, 20°C .]:	189
CC-3-V1	8.0%	V_o [V]:	1.93
CCH-35	5.0%		
CPY-2-02	12.0%		
CPY-3-02	12.0%		

Example 5

[0113]

PCH-304FF	11.0%	$S \rightarrow N$:	$<-30^\circ\text{C}$.
PCH-504FF	16.0%	Clearing point [$^\circ\text{C}$.]:	83.5
CC-5-V	12.0%	Δn [589 nm, 20°C .]:	+0.1006
PCH-302	6.0%	$\Delta\epsilon$ [1 kHz, 20°C .]:	-3.7
CCH-35	5.0%	$\epsilon_{ }$ [1 kHz, 20°C .]:	3.5
CC-3-V1	8.0%	γ_1 [mPa \cdot s, 20°C .]:	150
CPY-2-02	12.0%	V_o [V]:	2.23
CPY-3-02	12.0%		
CCP-302FF	11.0%		
CCP-V2-1	7.0%		

Example 6

[0114]

PCH-502FF	8.0%	$S \rightarrow N$:	$<-30^\circ\text{C}$.
PCH-504FF	16.0%	Clearing point [$^\circ\text{C}$.]:	70.5
PCH-301	9.0%	Δn [589 nm, 20°C .]:	+0.1007
CCP-V2-1	5.0%	$\Delta\epsilon$ [1 kHz, 20°C .]:	-4.2
CC-3-V1	9.0%	$\epsilon_{ }$ [1 kHz, 20°C .]:	3.9

-continued

CCH-35	5.0%	γ_1 [mPa \cdot s, 20°C .]:	139
CC-5-V	6.0%	V_o [V]:	1.96
D-302-FF	8.0%		
D-502FF	8.0%		
CPY-2-02	14.0%		
CPY-3-02	12.0%		

Example 7

[0115]

PCH-304FF	14.0%	$S \rightarrow N$:	$<-30^\circ\text{C}$.
PCH-502FF	7.0%	Clearing point [$^\circ\text{C}$.]:	80.5
PCH-504FF	18.0%	Δn [589 nm, 20°C .]:	+0.1006
CC-5-V	8.0%	$\Delta\epsilon$ [1 kHz, 20°C .]:	-4.9
CC-3-V1	8.0%	$\epsilon_{ }$ [1 kHz, 20°C .]:	3.8
CCH-35	5.0%	γ_1 [mPa \cdot s, 20°C .]:	186
CPY-2-02	12.0%	V_o [V]:	1.89
CPY-3-02	12.0%		
CCP-302FF	13.0%		
CCPC-33	3.0%		

Example 8

[0116]

PCH-304FF	14.0%	$S \rightarrow N$:	$<-30^\circ\text{C}$.
PCH-502FF	10.0%	Clearing point [$^\circ\text{C}$.]:	80.0
PCH-504FF	17.0%	Δn [589 nm, 20°C .]:	+0.1104
CCH-35	5.0%	$\Delta\epsilon$ [1 kHz, 20°C .]:	-5.1
CC-3-V1	9.0%	$\epsilon_{ }$ [1 kHz, 20°C .]:	3.8
BCH-32	6.0%	γ_1 [mPa \cdot s, 20°C .]:	202
CPY-2-02	13.0%	V_o [V]:	1.83
CPY-3-02	12.0%		
CCP-302FF	14.0%		

Example 9

[0117]

PCH-304FF	14.0%	$S \rightarrow N$:	$<-30^\circ\text{C}$.
PCH-502FF	8.0%	Clearing point [$^\circ\text{C}$.]:	70.0
PCH-504FF	15.0%	Δn [589 nm, 20°C .]:	+0.0906
CCP-302FF	8.0%	$\Delta\epsilon$ [1 kHz, 20°C .]:	-3.7
CPY-2-02	9.0%	$\epsilon_{ }$ [1 kHz, 20°C .]:	3.6
CPY-3-02	10.0%	γ_1 [mPa \cdot s, 20°C .]:	119
CCP-V2-1	5.0%	V_o [V]:	2.03
CC-3-V1	8.0%		
CCH-35	5.0%		
CC-5-V	18.0%		

Example 10

[0118]

PCH-304FF	18.0%	$S \rightarrow N$:	$<-30^\circ\text{C}$.
PCH-502FF	10.0%	Clearing point [$^\circ\text{C}$.]:	80.5
PCH-504FF	15.0%	Δn [589 nm, 20°C .]:	+0.1192

-continued

CCP-302FF	10.0%	$\Delta\epsilon$ [1 kHz, 20° C.]:	-5.1
BCH-32	8.0%	ϵ_{ij} [1 kHz, 20° C.]:	4.0
CCP-V-1	10.0%	γ_1 [mPa · s, 20° C.]:	225
PCH-302	3.0%	V_o [V]:	1.83
PGIGI-3-F	2.0%		
CPY-2-02	12.0%		
CPY-3-02	12.0%		

Example 11

[0119]

PCH-304FF	15.0%	S → N:	< -30° C.
PCH-504FF	15.0%	Clearing point [° C.]:	79.0
CCH-35	5.0%	Δn [589 nm, 20° C.]:	+0.1122
CC-5-V	12.0%	$\Delta\epsilon$ [1 kHz, 20° C.]:	-3.7
CC-3-V1	10.0%	ϵ_{ij} [1 kHz, 20° C.]:	3.6
BCH-32	8.0%	V_o [V]:	2.04
CPY-2-02	10.0%	γ_1 [mPa · s, 20° C.]:	145
CPY-3-02	7.0%		
CPY-V-02	10.0%		
CPY-V-04	8.0%		

Example 12

[0120]

PCH-304FF	10.0%	S → N:	< -30° C.
PCH-504FF	16.0%	Clearing point [° C.]:	80.0
CCH-35	5.0%	Δn [589 nm, 20° C.]:	+0.1021
CC-5-V	20.0%	$\Delta\epsilon$ [1 kHz, 20° C.]:	-3.5
CC-3-V1	10.0%	ϵ_{ij} [1 kHz, 20° C.]:	3.5
BCH-32	3.0%	V_o [V]:	2.17
CPY-2-02	10.0%	γ_1 [mPa · s, 20° C.]:	131
CPY-3-02	10.0%	LTS in cells:	nem. > 1 000 h
CPY-V-02	10.0%	at -20° C., -30° C.	
CCP-302FF	6.0%		

Example 13

[0121]

PCH-304FF	14.0%	S → N:	< -30° C.
PCH-504FF	15.0%	Clearing point [° C.]:	84.0
CCY-V-02	10.0%	Δn [589 nm, 20° C.]:	+0.1140
CPY-3-1	9.0%	$\Delta\epsilon$ [1 kHz, 20° C.]:	-4.8
CC-3-V1	10.0%	ϵ_{ij} [1 kHz, 20° C.]:	3.8
CCH-35	5.0%	V_o [V]:	1.94
CC-5-V	7.0%	γ_1 [mPa · s, 20° C.]:	183
CPY-V-02	10.0%	LTS in cells:	nem. > 1 000 h
CPY-2-02	10.0%	at -20° C.	
CPY-3-02	10.0%		

Example 14

[0122]

PCH-304FF	20.0%	S → N:	< -40° C.
PCH-504FF	16.0%	Clearing point [° C.]:	69.0
BCH-32	8.0%	Δn [589 nm, 20° C.]:	+0.0978
CCP-V-1	8.0%	$\Delta\epsilon$ [1 kHz, 20° C.]:	-3.0
CC-3-V1	8.0%	ϵ_{ij} [1 kHz, 20° C.]:	3.6
CC-5-V	20.0%	V_o [V]:	2.17
CPY-2-02	10.0%	γ_1 [mPa · s, 20° C.]:	108
CPY-3-02	10.0%	LTS in cells:	nem. > 1 000 h
		at -20° C., -30° C., -40° C.	

Example 15

[0123]

PCH-304FF	16.0%	S → N:	< -30° C.
PCH-504FF	18.0%	Clearing point [° C.]:	73.5
CCP-302FF	6.0%	Δn [589 nm, 20° C.]:	+0.0883
CPY-2-02	6.0%	$\Delta\epsilon$ [1 kHz, 20° C.]:	-3.1
CPY-3-02	11.0%	ϵ_{ij} [1 kHz, 20° C.]:	3.4
CCP-V2-1	10.0%	V_o [V]:	2.26
CC-3-V1	8.0%	γ_1 [mPa · s, 20° C.]:	113
CCH-35	5.0%	LTS in cells:	nem. > 1 000 h
CC-5-V	20.0%	at -20° C. and -30° C.	

Example 16

[0124]

PCH-304FF	13.0%	Clearing point [° C.]:	70
PCH-502FF	8.0%	Δn [589 nm, 20° C.]:	+0.0986
PCH-504FF	11.0%	$\Delta\epsilon$ [1 kHz, 20° C.]:	-3.2
CPY-3-02	10.0%	ϵ_{ij} [1 kHz, 20° C.]:	3.6
CPQIY-3-02	5.0%	V_o [V]:	2.12
CPQIY-3-04	5.0%	γ_1 [mPa · s, 20° C.]:	116
CPY-2-02	9.0%		
BCH-32	8.0%		
CC-3-V1	8.0%		
CCH-35	5.0%		
CC-5-V	18.0%		

Example 17

[0125]

PCH-304FF	16.0%	Clearing point [° C.]:	70.5
PCH-502FF	8.0%	Δn [589 nm, 20° C.]:	+0.0954
PCH-504FF	12.0%	$\Delta\epsilon$ [1 kHz, 20° C.]:	-3.4
CPY-3-02	8.0%	ϵ_{ij} [1 kHz, 20° C.]:	3.6
CPQY-3-02	5.0%	V_o [V]:	2.08
CPQY-5-02	5.0%	γ_1 [mPa · s, 20° C.]:	122
CPY-2-02	9.0%		
BCH-32	8.0%		
CC-3-V1	8.0%		
CCH-35	5.0%		
CC-5-V	16.0%		

Example 18

[0126]

PCH-304FF	8.0%	Clearing point [° C.]:	70.0
PCH-502FF	10.0%	Δn [589 nm, 20° C.]:	+0.1023
PCH-504FF	14.0%	$\Delta \epsilon$ [1 kHz, 20° C.]:	-3.3
CPY-3-02	12.0%	$\epsilon_{ }$ [1 kHz, 20° C.]:	3.6
CQY-5-1	5.0%	V_o [V]:	2.14
CQY-3-04	5.0%	γ_1 [mPa · s, 20° C.]:	104
CPY-3-04	12.0%		
BCH-32	9.0%		
CC-3-V1	10.0%		
CCH-35	5.0%		
CC-5-V	10.0%		

Example 19

[0127]

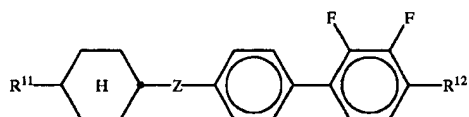
PCH-304FF	11.0%	Clearing point [° C.]:	69.5
PCH-502FF	9.0%	Δn [589 nm, 20° C.]:	+0.0952
PCH-504FF	16.0%	$\Delta \epsilon$ [1 kHz, 20° C.]:	-3.6
CPQY-3-02	8.0%	$\epsilon_{ }$ [1 kHz, 20° C.]:	3.6
CPY-2-04	10.0%	V_o [V]:	2.08
CPY-3-02	11.0%	γ_1 [mPa · s, 20° C.]:	120
CCPC-33	3.0%		
CC-3-V1	8.0%		
CCH-35	5.0%		
CC-5-V	19.0%		

Example 20

[0128]

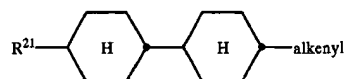
PCH-304FF	13.0%	Clearing point [° C.]:	70.5
PCH-502FF	8.0%	Δn [589 nm, 20° C.]:	+0.0900
PCH-504FF	16.0%	$\Delta \epsilon$ [1 kHz, 20° C.]:	-3.7
CCQY-3-02	8.0%	$\epsilon_{ }$ [1 kHz, 20° C.]:	3.6
CPY-2-02	10.0%	V_o [V]:	2.06
CPY-3-02	10.0%	γ_1 [mPa.s, 20° C.]:	119
CCP-V2-1	4.0%		
CC-3-V1	8.0%		
CCH-35	5.0%		
CC-5-V	18.0%		

1. A liquid-crystalline medium based on a mixture of polar compounds having negative dielectric anisotropy, comprising at least one compound of formula I1



I1

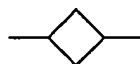
and at least one compound of formula I2



I2

in which

R^{11} , R^{12} and R^{21} are each, independently of one another, alkyl or alkenyl having up to 15 carbon atoms which is unsubstituted, monosubstituted by CN or CF_3 or at least monosubstituted by halogen, where one or more CH_2 groups in these radicals may also, in each case independently of one another, be replaced by $-O-$, $-S-$,

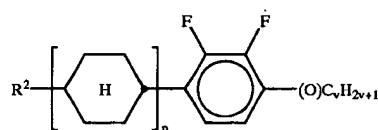


$-C=C-$, $-CO-$, $-CO-O-$, $-O-CO-$ or $-O-CO-O-$ in such a way that O atoms are not linked directly to one another,

Z is $-C_2H_4-$, $-CH=CH-$, $-CF_2O-$, $-OCF_2-$ or a single bond, and

alkenyl is straight-chain alkenyl having 2-6 carbon atoms.

2. The medium according to claim 1, additionally comprising at least one compound of formula II



II

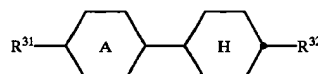
in which

R^2 is independently as defined for R^{11} , R^{12} and R^{21} ,

p is 1 or 2, and

v is 1 to 6.

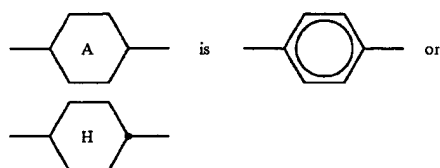
3. The medium according to claim 1, additionally comprising at least one compound of formula III



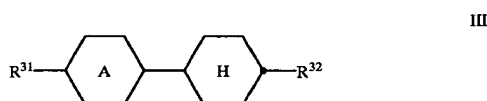
III

in which

R^{31} and R^{32} are each, independently of one another, a straight-chain alkyl or alkyloxy radical having 1-12 carbon atoms, and

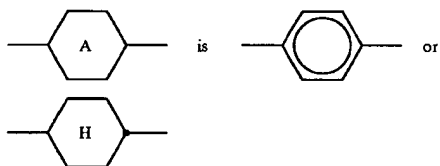


4. The medium according to claim 2, additionally comprising at least one compound of formula III



in which

R^{31} and R^{32} are each, independently of one another, a straight-chain alkyl or alkoxy radical having 10-12 carbon atoms, and



5. The medium according to claim 1, comprising at least three compounds of formulae I1 or I2.

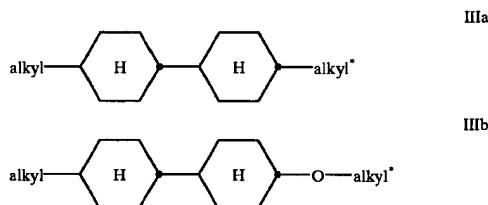
6. The medium according to claim 1, having a proportion of compounds of formula I1 in the total mixture of at least 10% by weight.

7. The medium according to claim 1, having a proportion of compounds of formula I2 in the total mixture of at least 5% by weight.

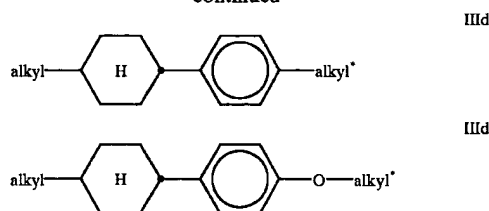
8. The medium according to claim 2, having a proportion of compounds of formula II in the total mixture of at least 20% by weight.

9. The medium according to claim 3, having a proportion of compounds of formula III in the total mixture of at least 5% by weight.

10. The liquid-crystalline medium according to claim 3, comprising at least one compound of formulae IIIa to IIId:



-continued



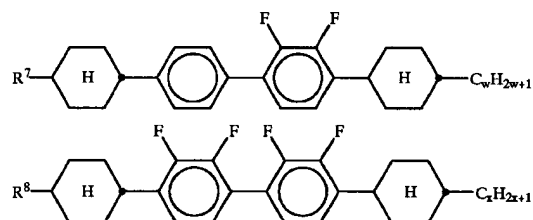
in which

alkyl and

alkyl* are each, independently of one another, straight-chain alkyl having 1-6 carbon atoms.

11. The liquid-crystalline medium according to claim 10, comprising at least one compound of formula IIIa, at least one compound of formula IIIb, or a mixture thereof.

12. The liquid-crystalline medium according to claim 1, additionally comprising at least one compound of the formulae



in which

R^7 and R^8 are each, independently of one another, as defined for R^{11} , R^{12} and R^{21} , and

w and x are each, independently of one another, from 1 to 6.

13. The liquid-crystalline medium according to claim 2, comprising

10-40% by weight of at least one compound of formula I1,

5-30% by weight of at least one compound of formula I2, and

20-70% by weight of at least one compound of formula II.

14. An electro-optical display having active matrix addressing based on ECB effect or IPS effect, comprising as a dielectric, a liquid-crystalline medium according to claim 1.

15. An electro-optical display comprising, as a dielectric, a liquid-crystalline medium according to claim 1.

16. An electro-optical display comprising, as a dielectric, a liquid-crystalline medium according to claim 2.

17. An electro-optical display comprising, as a dielectric, a liquid-crystalline medium according to claim 3.

* * * * *

WEST

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L3: Entry 2 of 2

File: PGPB

Feb 7, 2002`

DOCUMENT-IDENTIFIER: US 20020014613 A1

TITLE: Liquid-crystalline medium

Detail Description Table CWU (16):

17 PCH-304FF 13.0% Clearing point [.degree. C.]: 70 PCH-502FF 8.0% .DELTA.n [589 nm, 20.degree. C.]: +0.0986 PCH-504FF 11.0% .DELTA..epsilon. [1 kHz, 20.degree. C.]: -3.2 CPY-3-02 10.0% .epsilon..sub..parallel. [1 kHz, 20.degree. C.]: 3.6 CPQIY-3-02 5.0% V.sub.o [V]: 2.12 CPQIY-3-04 5.0% .gamma..sub.1 [mPa .multidot. s, 20.degree. C.]: 116 CPY-2-02 9.0% BCH-32 8.0% CC-3-V1 8.0% CCH-35 5.0% CC-5-V 18.0%

Detail Description Table CWU (19):

20 PCH-304FF 11.0% Clearing point [.degree. C.]: 69.5 PCH-502FF 9.0% .DELTA.n [589 nm, 20.degree. C.]: +0.0952 PCH-504FF 16.0% .DELTA..epsilon. [1 kHz, 20.degree. C.]: -3.6 CPQIY-3-02 8.0% .epsilon..sub..parallel. [1 kHz, 20.degree. C.]: 3.6 CPY-2-04 10.0% V.sub.o [V] 2.08 CPY-3-02 11.0% .gamma..sub.1 [mPa .multidot. s, 20.degree. C.] 120 CCPC-33 3.0% CC-3-V1 8.0% CCH-35 5.0% CC-5-V 19.0%

WEST**End of Result Set**☐

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Print

L6: Entry 2 of 2

File: PGPB

Feb 7, 2002

DOCUMENT-IDENTIFIER: US 20020014613 A1

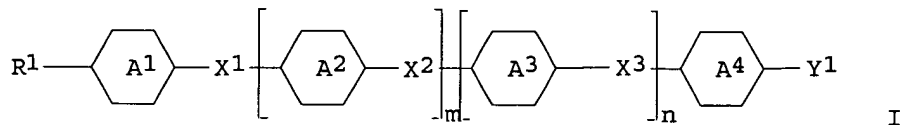
TITLE: Liquid-crystalline medium

Detail Description Table CWU (18):

19 PCH-304FF 8.0% Clearing point [.degree. C.]: 70.0 PCH-502FF 10.0% .DELTA.n [589 nm, 20.degree. C.]: +0.1023 PCH-504FF 14.0% .DELTA..epsilon. [1 kHz, 20.degree. C.]: -3.3 CPY-3-02 12.0% .epsilon..sub..parallel. [1 kHz, 20.degree. C.]: 3.6 CQY-5-1 5.0% V.sub.o [V]: 2.14 CQY-3-04 5.0% .gamma..sub.1 [mPa .multidot. s, 20.degree. C.]: 104 CPY-3-04 12.0% BCH-32 9.0% CC-3-V1 10.0% CCH-35 5.0% CC-5-V 10.0%

Takeshita, Fusayuki; et al.
 PA Chisso Corp., Japan; Ando, Tsugumichi; Matsui, Shuichi; Miyazawa, Kazutoshi; Takeuchi, Hiroyuki; Koizumi, Yasuyuki; Sekiguchi, Yasuko
 SO PCT Int. Appl., 222 pp.
 CODEN: PIXXD2
 DT Patent
 LA Japanese
 IC ICM C07C043-192
 ICS C07C043-225; C07C069-75; C07C069-753; C07C069-757; C07C069-76; C09K019-20; C09K019-30; C09K019-42; G02F001-13
 CC 75-11 (Crystallography and Liquid Crystals)
 Section cross-reference(s): 74
 FAN.CNT 1

	PATENT NO.	KIND	DATE	APPLICATION NO.	DATE
PI	WO 9736847	A1	19971009	WO 1997-JP1048	19970327
	W: AL, AU, BA, BB, BG, BR, CA, CN, CU, CZ, EE, GE, HU, IL, IS, JP, KR, LC, LK, LR, LT, LV, MG, MK, MN, MX, NO, NZ, PL, RO, SG, SI, SK, TR, TT, UA, US, UZ, VN, YU, AM, AZ, BY, KG, KZ, MD, RU, TJ, TM				
	RW: GH, KE, LS, MW, SD, SZ, UG, AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG				
	AU 9720434	A1	19971022	AU 1997-20434	19970327
	EP 916639	A1	19990519	EP 1997-908523	19970327
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	R: AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LI, LU, NL, SE, PT, IE				
	CN 1218451	A	19990602	CN 1997-194642	19970327
	EP 1043299	A2	20001011	EP 2000-113173	19970327
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	JP 3231333	B2	20011119	JP 1997-535120	19970327
	JP 2002053529	A2	20020219	JP 2001-181798	19970327
	AT 219041	E	20020615	AT 1997-908523	19970327
	TW 416979	B	20010101	TW 1997-86104142	19970328
	US 6190576	B1	20010220	US 1998-155595	19980930
	US 6319570	B1	20011120	US 2000-597280	20000619
PRAI	JP 1996-79946	A	19960402		
	JP 1996-239751	A	19960822		
	EP 1997-908523	A3	19970327		
	JP 1997-535120	A3	19970327		
	WO 1997-JP1048	W	19970327		
	US 1998-155595	A1	19980930		
OS	MARPAT 127:301549				
GI					



AB The above liq. crystal compds. represented by general formula (I; R1, Y1 = C1-20 alkyl; X1, X2, X3 = a single bond, 1,2-ethylene, vinylene, CO2, CF2O or OCF2; A1, A2, A3, A4 = trans-1,4-cyclohexylene or optionally fluorinated or chlorinated 1,4-phenylene, at least one of A2, A3 and A4 being 2,3-difluoro-1,4-phenylene; m, n = 0 or 1) with the proviso that the elements constituting the compds. may be each replaced by isotopes thereof are prepd. Liq. crystal compns. contg. the compds. I and liq. crystal display devices made by using the compns. are claimed. These liq. crystal compds. are low in viscosity and high in dielec. anisotropy and have high specific resistance and high voltage retention, and are stable even when exposed to heat and UV rays. Thus, 2,3-difluoro-4-ethoxyphenol was

condensed with 2-fluoro-4-[2-(trans-4-propylcyclohexyl)ethyl]benzoic acid using DCC in the presence of 4-dimethylaminopyridine at room temp. overnight to give 2,3-difluoro-4-ethoxyphenyl 2-fluoro-4-[2-(trans-4-propylcyclohexyl)ethyl]benzoate (II), which showed phase transition temp. 65.4.degree. for C-N point and 141.3.degree. for N-I point. A liq. crystal compn. contg. 15 wt.% II and a mother liq. crystal compn. (85 wt.%) consisting of 4-butoxyphenyl 4-(trans-4-propylcyclohexyl)carboxybenzoate 27.6, 4-ethoxyphenyl 4-(trans-4-butylcyclohexyl)carboxybenzoate 20.7, 4-methoxyphenyl 4-(trans-4-pentylcyclohexyl)carboxybenzoate 20.7, 4-ethoxyphenyl 4-(trans-4-propylcyclohexyl)carboxybenzoate 17.2, and 4-ethoxyphenyl 4-(trans-4-pentylcyclohexyl)carboxybenzoate 13.8 wt.% showed clearing point 129.4.degree. and dielec. anisotropy (.DELTA..epsilon.) -4.17 as compared to 74.6.degree. and 0.0, resp., for the mother liq. crystal compn.

ST liq crystal compn display device; phenyl cyclohexylethylbenzoate prepn liq crystal

IT Liquid crystal displays
Liquid crystals

(prepn. of liq. crystal compds., liq. crystal compns. contg. the compds., and liq. crystal display devices made by using them)

IT	22692-80-4	38444-13-2	38690-77-6	40817-08-1	41122-71-8
	50649-59-7	50649-60-0	52709-83-8	56131-48-7	56131-49-8
	57202-28-5	57202-30-9	57202-37-6	57202-38-7	58743-75-2
	59855-05-9	61203-99-4	61204-01-1	61204-03-3	63221-88-5
	63295-01-2	64240-64-8	64835-59-2	67589-39-3	67589-41-7
	67589-46-2	67589-47-3	67589-52-0	67589-53-1	68400-50-0
	70567-18-9	72928-54-2	74305-48-9	75941-46-7	75941-48-9
	75941-50-3	75941-51-4	75941-52-5	75941-90-1	76802-59-0
	76802-61-4	79319-27-0	79709-84-5	79832-86-3	79912-85-9
	79945-42-9	80944-44-1	80955-71-1	81701-13-5	81711-13-9
	81793-57-9	81793-59-1	81936-32-5	82832-27-7	82832-33-5
	82832-34-6	82832-57-3	82985-80-6	82991-48-8	83242-83-5
	84540-37-4	84655-98-1	84656-75-7	84656-77-9	84656-92-8
	85312-59-0	86377-38-0	86579-52-4	86778-48-5	86786-89-2
	86840-79-1	87073-93-6	87260-24-0	88038-92-0	88416-69-7
	88416-84-6	88416-89-1	88639-41-2	88878-50-6	89129-90-8
	92263-41-7	93743-04-5	95495-03-7	95495-15-1	95495-17-3
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	197012-76-3	197012-77-4	197012-78-5	197012-79-6	197012-83-2

197012-84-3 197012-85-4 197012-86-5 197012-87-6

RL: DEV (Device component use); TEM (Technical or engineered material use); USES (Uses)

(liq. crystal compn. contg.; prepn. of liq. crystal compds., liq. crystal compns. contg. the compds., and liq. crystal display devices made by using them)

IT 197012-57-0 197012-58-1 **197012-59-2** 197012-60-5
197012-61-6 197012-62-7 **197012-70-7** **197012-74-1**
197012-80-9 197012-81-0 **197012-82-1**

RL: DEV (Device component use); TEM (Technical or engineered material use); USES (Uses)

(liq. crystal compn.; prepn. of liq. crystal compds., liq. crystal compns. contg. the compds., and liq. crystal display devices made by using them)

IT 197012-44-5P **197012-45-6P** 197012-46-7P 197012-47-8P
197012-48-9P 197012-49-0P 197012-50-3P **197012-51-4P**
197012-52-5P 197012-53-6P 197012-54-7P 197012-55-8P 197012-56-9P

RL: DEV (Device component use); SPN (Synthetic preparation); TEM (Technical or engineered material use); PREP (Preparation); USES (Uses)

(prepn. of liq. crystal compds., liq. crystal compns. contg. the compds., and liq. crystal display devices made by using them)

IT 74-96-4, Ethyl bromide 75-15-0, Carbon disulfide, reactions 121-43-7, Trimethyl borate 1031-15-8, Methyltriphenylphosphonium chloride 4009-98-7, Methoxymethyltriphenylphosphonium chloride 4746-97-8, 1,4-Cyclohexanedione monoethylene ketal 6418-38-8, 2,3-Difluorophenol 6793-92-6, Benzyl 4-Bromophenyl ether 14938-35-3, 4-Pentylphenol 65355-32-0, trans-4-(trans-4-Propylcyclohexyl)cyclohexanecarboxylic acid 69891-92-5, 2-(1,3-Dioxan-2-yl)ethyltriphenylphosphonium bromide 79832-89-6, 4-(trans-4-n-Pentylcyclohexyl)phenyl bromide 81936-33-6, 4-(trans-4-Propylcyclohexyl)phenol 86579-53-5, 4-(trans-4-Propylcyclohexyl)bromobenzene 132248-38-5

RL: RCT (Reactant); RACT (Reactant or reagent)

(prepn. of liq. crystal compds., liq. crystal compns. contg. the compds., and liq. crystal display devices made by using them)

IT 51171-73-4P, 4-(4-Hydroxyphenyl)cyclohexanone 121219-07-6P, 2,3-Difluoro-1-ethoxybenzene 121537-69-7P 126163-56-2P, 2,3-Difluoro-4-ethoxyphenol 197012-88-7P, 4-(trans-4-n-Pentylcyclohexyl)phenylmagnesium bromide 197012-89-8P, 4-(trans-4-n-Pentylcyclohexyl)phenyldithiocarboxylic acid 197012-90-1P 197012-91-2P, 4-(trans-4-Propylcyclohexyl)phenyldithiocarboxylic acid 197012-92-3P, 4-(trans-4-Propylcyclohexyl)phenylthiocarbonyl chloride 197012-93-4P, 4-Pentylphenyl 4-(trans-4-propylcyclohexyl)thiobenzoate 197012-94-5P 197012-95-6P, 4-Propylphenylthiocarbonyl chloride 197012-96-7P 197012-97-8P 197012-98-9P 197012-99-0P 197013-00-6P 197013-01-7P 197013-02-8P 197013-03-9P 197013-04-0P 197013-05-1P 197013-06-2P 197013-07-3P 197013-08-4P 197013-09-5P

RL: RCT (Reactant); SPN (Synthetic preparation); PREP (Preparation); RACT (Reactant or reagent)

(prepn. of liq. crystal compds., liq. crystal compns. contg. the compds., and liq. crystal display devices made by using them)

IT **197012-67-2**

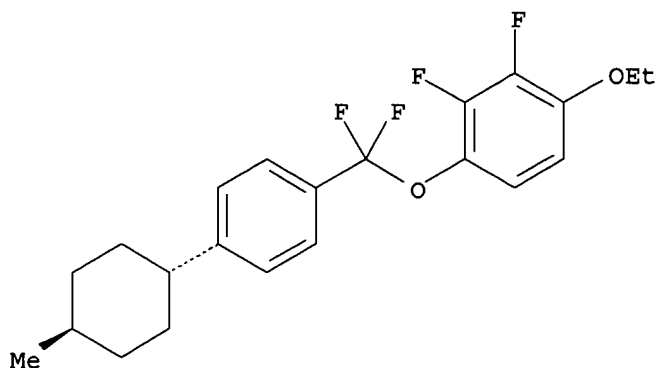
RL: DEV (Device component use); TEM (Technical or engineered material use); USES (Uses)

(liq. crystal compn. contg.; prepn. of liq. crystal compds., liq. crystal compns. contg. the compds., and liq. crystal display devices made by using them)

RN 197012-67-2 CAPLUS

CN Benzene, 1-[difluoro[4-(4-methylcyclohexyl)phenyl]methoxy]-4-ethoxy-2,3-difluoro-, trans- (9CI) (CA INDEX NAME)

Relative stereochemistry.



IT 197012-59-2 197012-70-7 197012-74-1
197012-80-9 197012-82-1

RL: DEV (Device component use); TEM (Technical or engineered material use); USES (Uses)

(liq. crystal compn.; prepn. of liq. crystal compds., liq. crystal compns. contg. the compds., and liq. crystal display devices made by using them)

RN 197012-59-2 CAPLUS

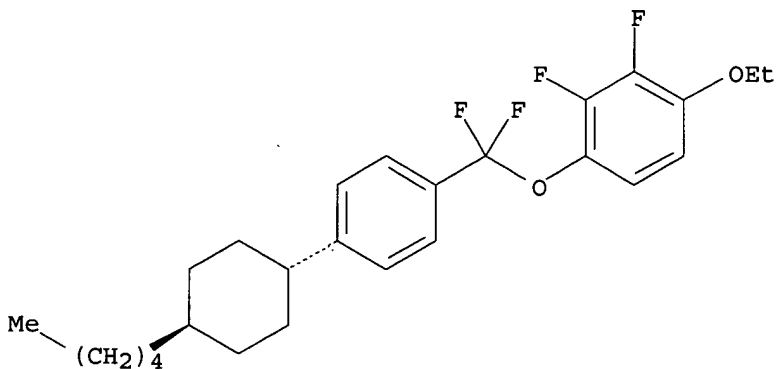
CN Benzoic acid, 4-[[[(4-butylcyclohexyl)carbonyl]oxy]-, 4-ethoxyphenyl ester, trans-, mixt. with trans-4-butoxyphenyl 4-[[[(4-propylcyclohexyl)carbonyl]oxy]benzoate, trans-1-[difluoro[4-(4-pentylcyclohexyl)phenyl]methoxy]-4-ethoxy-2,3-difluorobenzene, trans-4-ethoxyphenyl 4-[[[(4-pentylcyclohexyl)carbonyl]oxy]benzoate, trans-4-ethoxyphenyl 4-[[[(4-propylcyclohexyl)carbonyl]oxy]benzoate and trans-4-methoxyphenyl 4-[[[(4-pentylcyclohexyl)carbonyl]oxy]benzoate (9CI) (CA INDEX NAME)

CM 1

CRN 197012-45-6

CMF C26 H32 F4 O2

Relative stereochemistry.

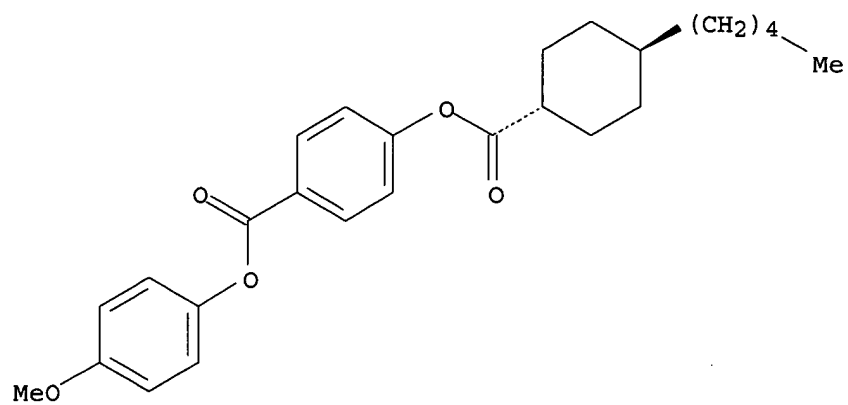


CM 2

CRN 70592-21-1

CMF C26 H32 O5

Relative stereochemistry.

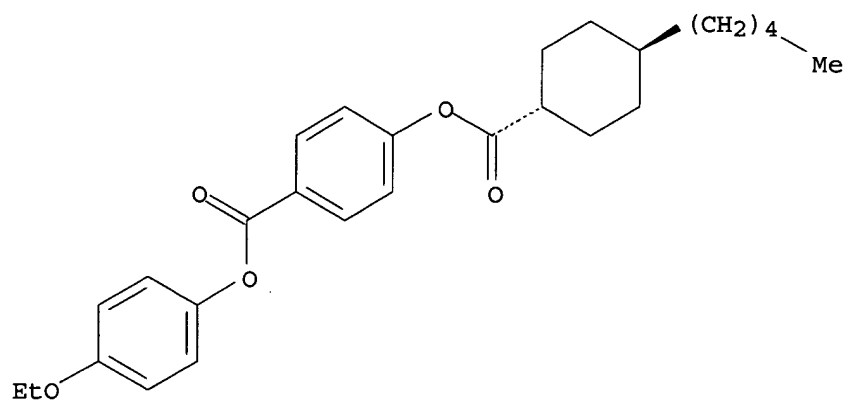


CM 3

CRN 70567-30-5

CMF C27 H34 O5

Relative stereochemistry.

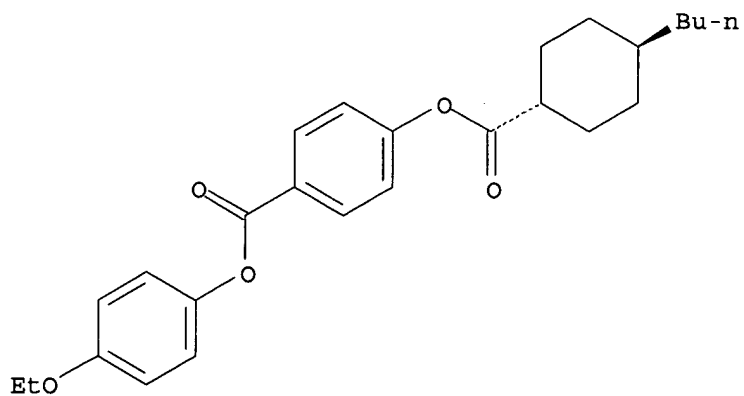


CM 4

CRN 70567-20-3

CMF C26 H32 O5

Relative stereochemistry.

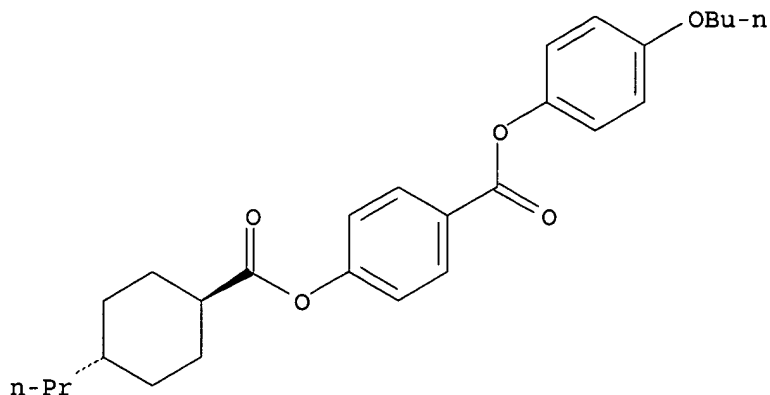


CM 5

CRN 70567-14-5

CMF C27 H34 O5

Relative stereochemistry.

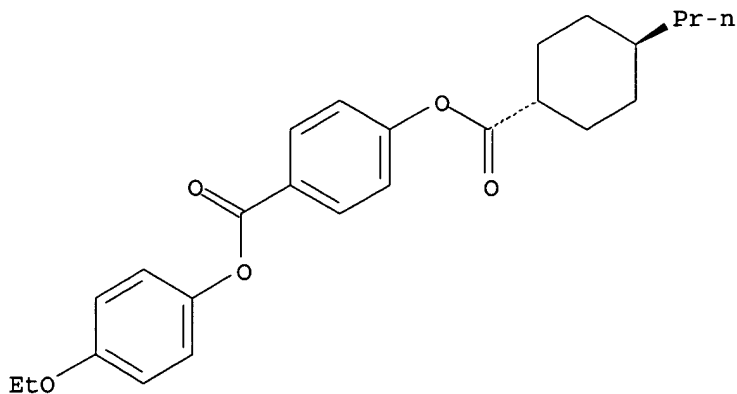


CM 6

CRN 70567-12-3

CMF C25 H30 O5

Relative stereochemistry.



RN 197012-70-7 CAPLUS

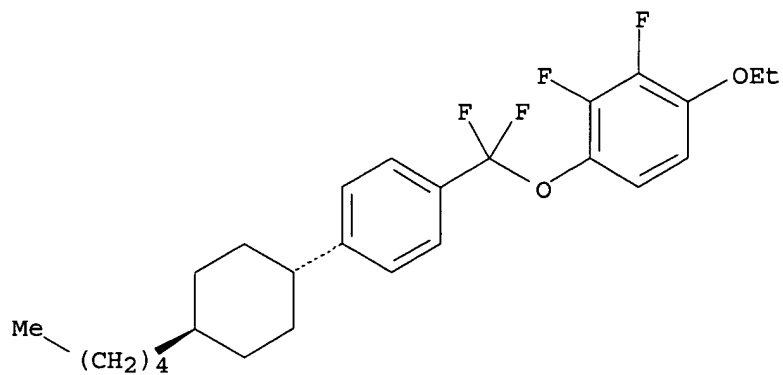
CN 1,1'-Biphenyl, 3,4-difluoro-4'-(4-pentylcyclohexyl)-, trans-, mixt. with [trans(trans)]-1,2-difluoro-4-(4'-pentyl[1,1'-bicyclohexyl]-4-yl)benzene, trans-1-[difluoro[4-(4-pentylcyclohexyl)phenyl]methoxy]-4-ethoxy-2,3-difluorobenzene, [trans(trans)]-1,2-difluoro-4-(4'-propyl[1,1'-bicyclohexyl]-4-yl)benzene, trans-3,4-difluoro-4'-(4-propylcyclohexyl)-1,1'-biphenyl, [trans(trans)]-1,2-difluoro-4-[4-[2-(4-propylcyclohexyl)ethyl]cyclohexyl]benzene, [trans(trans)]-4-(4'-ethyl[1,1'-bicyclohexyl]-4-yl)-1,2-difluorobenzene, trans-4'-(4-ethylcyclohexyl)-3,4-difluoro-1,1'-biphenyl and [trans(trans)]-4-[4-[2-(4-ethylcyclohexyl)ethyl]cyclohexyl]-1,2-difluorobenzene (9CI) (CA INDEX NAME)

CM 1

CRN 197012-45-6

CMF C26 H32 F4 O2

Relative stereochemistry.

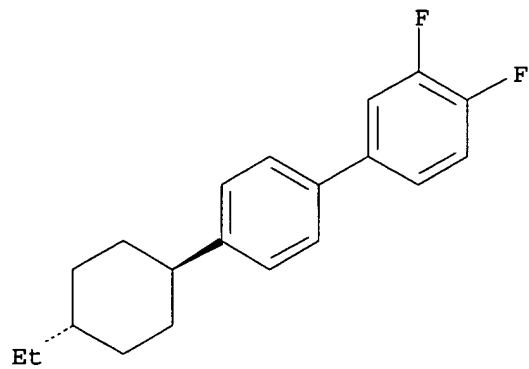


CM 2

CRN 134412-18-3

CMF C20 H22 F2

Relative stereochemistry.

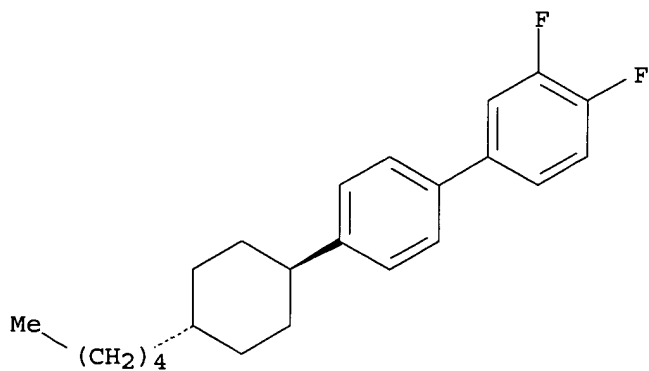


CM 3

CRN 134412-17-2

CMF C23 H28 F2

Relative stereochemistry.

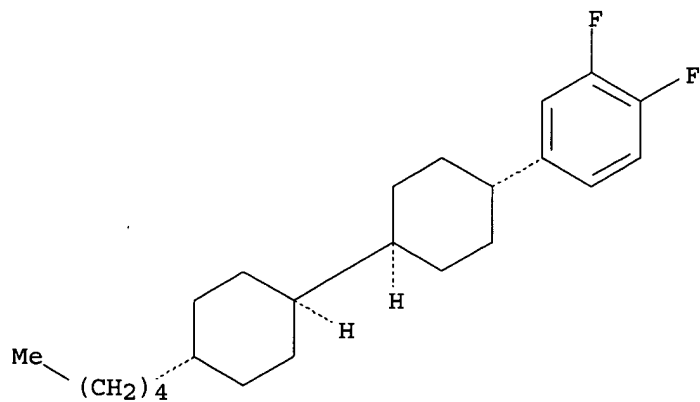


CM 4

CRN 118164-51-5

CMF C23 H34 F2

Relative stereochemistry.

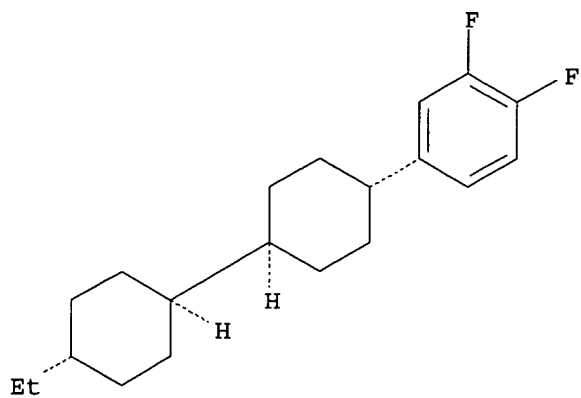


CM 5

CRN 118164-50-4

CMF C20 H28 F2

Relative stereochemistry.

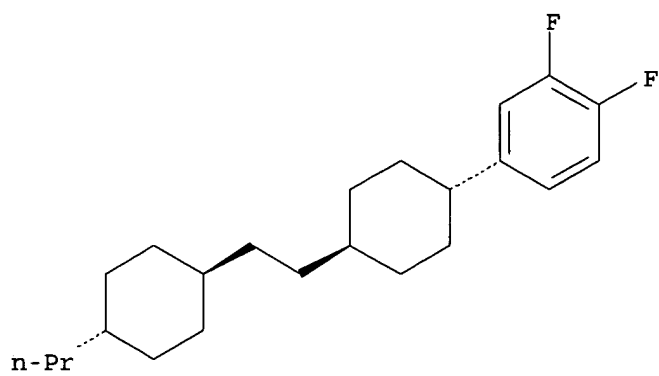


CM 6

CRN 117943-37-0

CMF C23 H34 F2

Relative stereochemistry.

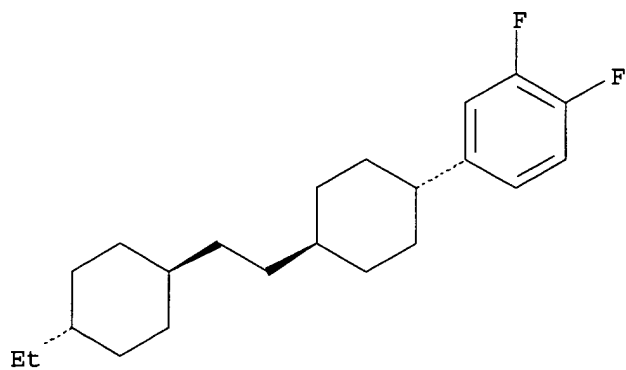


CM 7

CRN 117923-19-0

CMF C22 H32 F2

Relative stereochemistry.

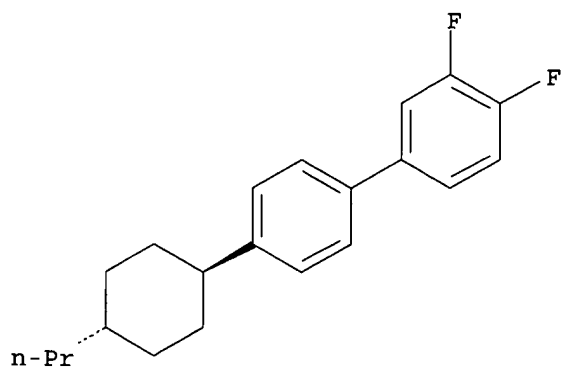


CM 8

CRN 85312-59-0

CMF C21 H24 F2

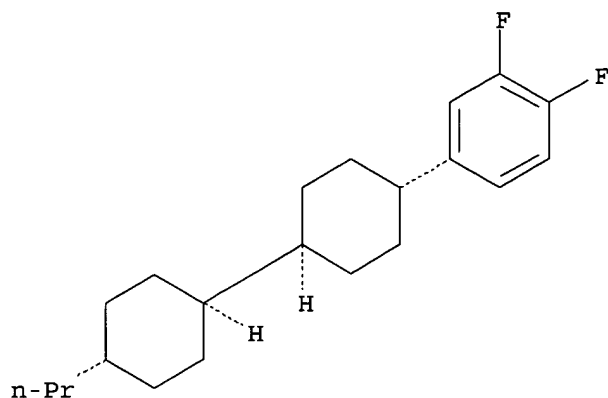
Relative stereochemistry.



CM 9

CRN 82832-57-3
CMF C21 H30 F2

Relative stereochemistry.

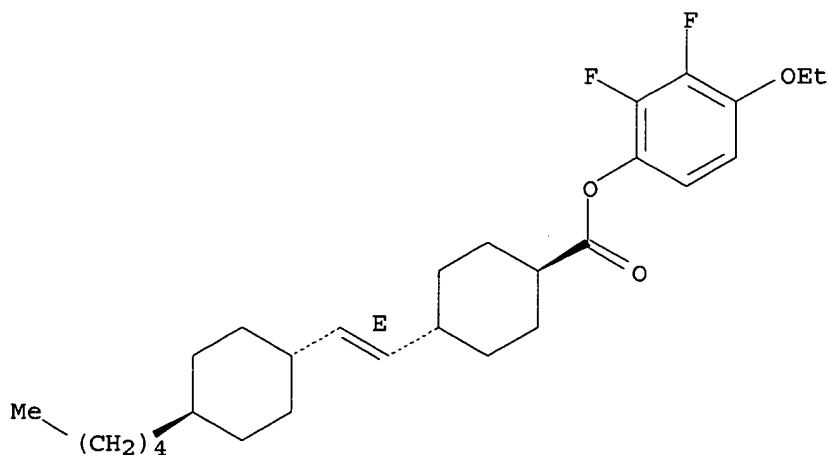


RN 197012-74-1 CAPLUS
CN Cyclohexanecarboxylic acid, 4-butyl-, 4-ethoxyphenyl ester, trans-, mixt.
with trans-4-butoxyphenyl 4-propylcyclohexanecarboxylate,
trans-1-butoxy-4-(4-propylcyclohexyl)benzene, trans-1-[difluoro[4-(4-
pentylcyclohexyl)phenyl]methoxy]-4-ethoxy-2,3-difluorobenzene,
[1.alpha.,4.beta.[E(trans)]]-4-ethoxy-2,3-difluorophenyl
4-[2-(4-pentylcyclohexyl)ethenyl]cyclohexanecarboxylate,
trans-4-ethoxyphenyl 4-pentylcyclohexanecarboxylate, trans-4-ethoxyphenyl
4-propylcyclohexanecarboxylate, trans-1-ethoxy-4-(4-
propylcyclohexyl)benzene and trans-4-methoxyphenyl 4-
pentylcyclohexanecarboxylate (9CI) (CA INDEX NAME)

CM 1

CRN 197012-52-5
CMF C28 H40 F2 O3

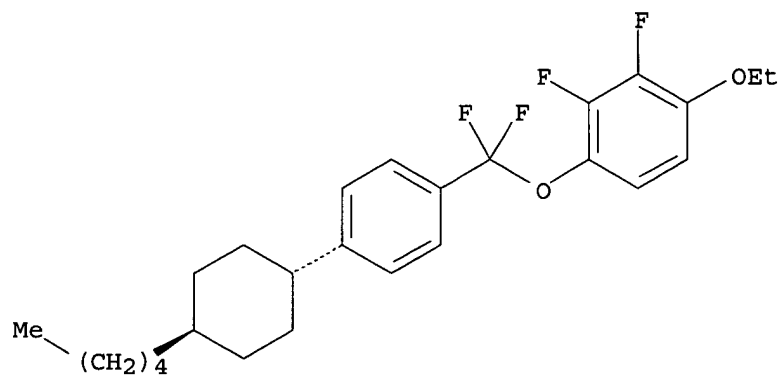
Relative stereochemistry.
Double bond geometry as shown.



CM 2

CRN 197012-45-6
CMF C26 H32 F4 O2

Relative stereochemistry.

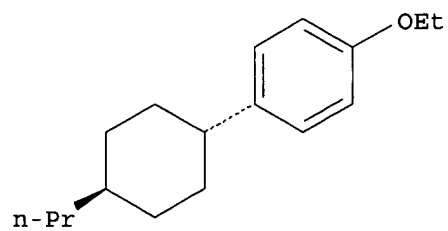


CM 3

CRN 80944-44-1

CMF C17 H26 O

Relative stereochemistry.

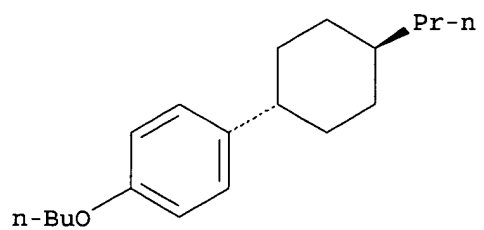


CM 4

CRN 79709-84-5

CMF C19 H30 O

Relative stereochemistry.

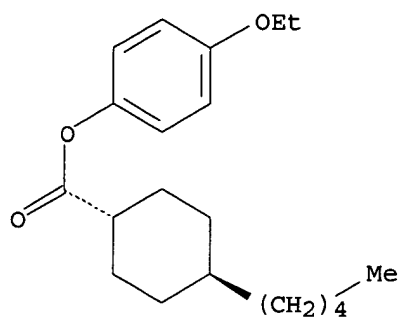


CM 5

CRN 67589-53-1

CMF C20 H30 O3

Relative stereochemistry.

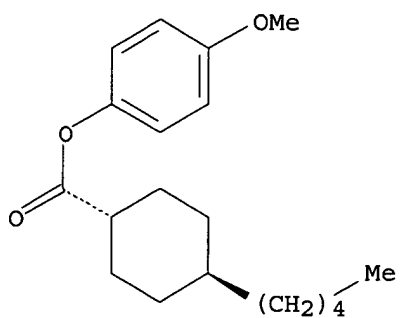


CM 6

CRN 67589-52-0

CMF C19 H28 O3

Relative stereochemistry.

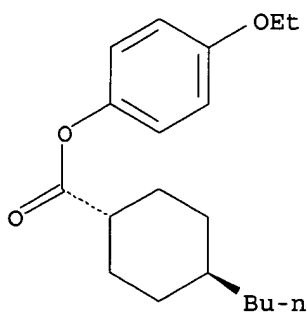


CM 7

CRN 67589-47-3

CMF C19 H28 O3

Relative stereochemistry.

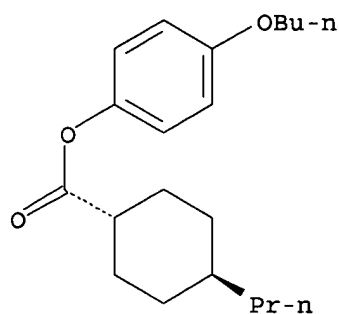


CM 8

CRN 67589-41-7

CMF C20 H30 O3

Relative stereochemistry.

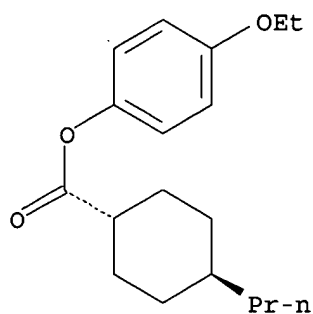


CM 9

CRN 67589-39-3

CMF C18 H26 O3

Relative stereochemistry.



RN 197012-80-9 CAPLUS

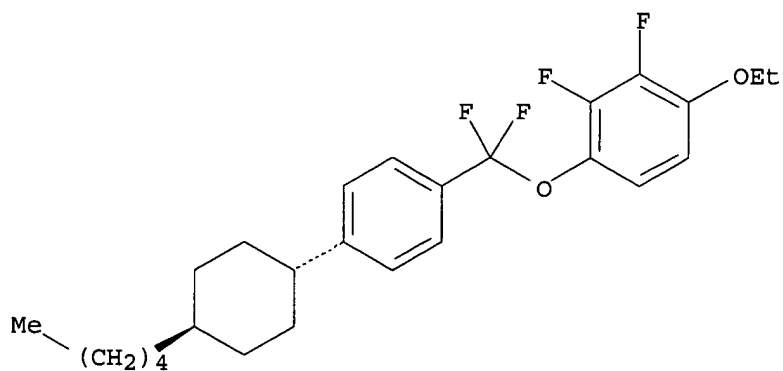
CN Cyclohexanecarboxylic acid, 4-butyl-, 4-ethoxyphenyl ester, trans-, mixt. with trans-4-butoxyphenyl 4-propylcyclohexanecarboxylate, trans-1-[difluoro[4-(4-pentylcyclohexyl)phenyl]methoxy]-4-ethoxy-2,3-difluorobenzene, trans-4-ethoxyphenyl 4-pentylcyclohexanecarboxylate, trans-4-ethoxyphenyl 4-propylcyclohexanecarboxylate and trans-4-methoxyphenyl 4-pentylcyclohexanecarboxylate (9CI) (CA INDEX NAME)

CM 1

CRN 197012-45-6

CMF C26 H32 F4 O2

Relative stereochemistry.

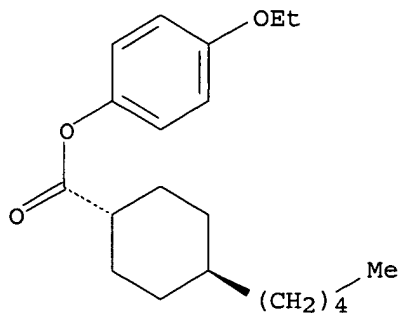


CM 2

CRN 67589-53-1

CMF C20 H30 O3

Relative stereochemistry.

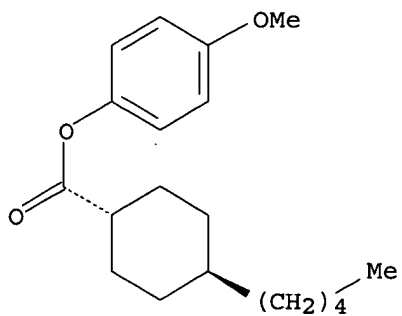


CM 3

CRN 67589-52-0

CMF C19 H28 O3

Relative stereochemistry.

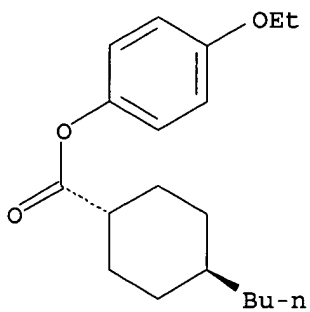


CM 4

CRN 67589-47-3

CMF C19 H28 O3

Relative stereochemistry.

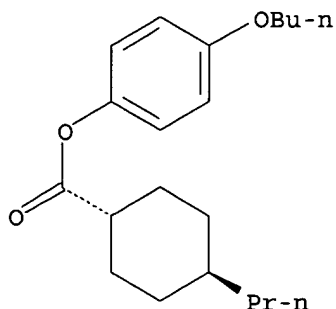


CM 5

CRN 67589-41-7

CMF C20 H30 O3

Relative stereochemistry.

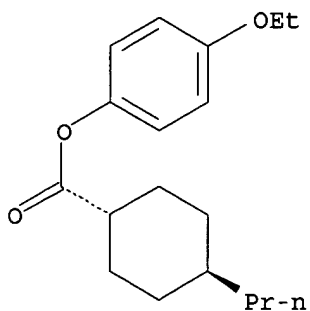


CM 6

CRN 67589-39-3

CMF C18 H26 O3

Relative stereochemistry.



RN 197012-82-1 CAPLUS

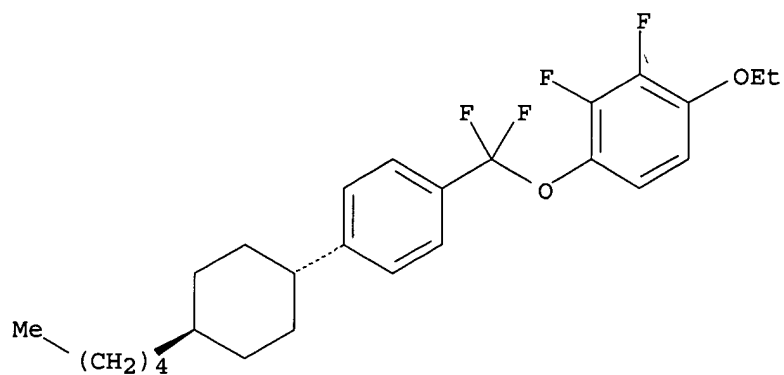
CN Benzoic acid, 2-fluoro-4-[2-(4-propylcyclohexyl)ethyl]-, 4-ethoxy-2,3-difluorophenyl ester, trans-, mixt. with 4-butoxy-2,3-difluoro-4'-pentyl-1,1'-biphenyl, 4-butoxy-2,3-difluoro-4'-propyl-1,1'-biphenyl, 2',3'-difluoro-4,4''-dipentyl-1,1':4',1''-terphenyl, 2',3'-difluoro-4-heptyl-4''-pentyl-1,1':4',1''-terphenyl, trans-1-[difluoro[4-(4-pentylcyclohexyl)phenyl]methoxy]-4-ethoxy-2,3-difluorobenzene, 2',3'-difluoro-4-pentyl-4''-propyl-1,1':4',1''-terphenyl, 4-ethoxy-2,3-difluoro-4'-propyl-1,1'-biphenyl and 4-ethyl-2',3'-difluoro-4''-propyl-1,1':4',1''-terphenyl (9CI) (CA INDEX NAME)

CM 1

CRN 197012-45-6

CMF C26 H32 F4 O2

Relative stereochemistry.

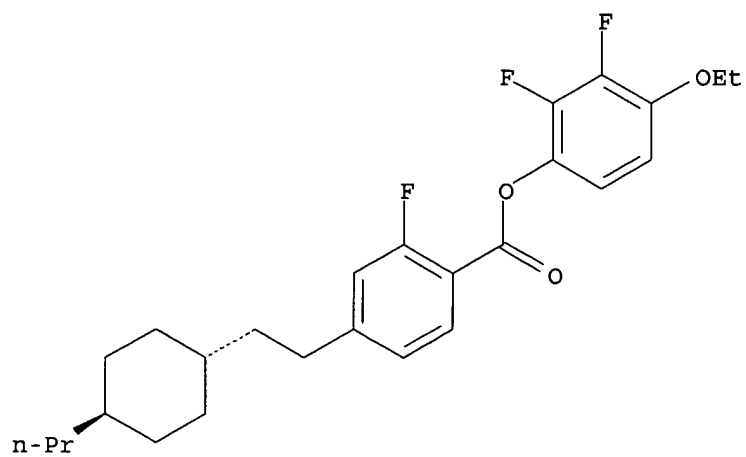


CM 2

CRN 197012-44-5

CMF C26 H31 F3 O3

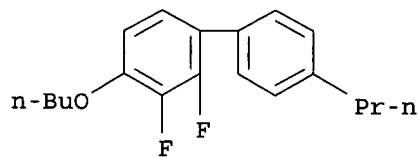
Relative stereochemistry.



CM 3

CRN 157248-28-7

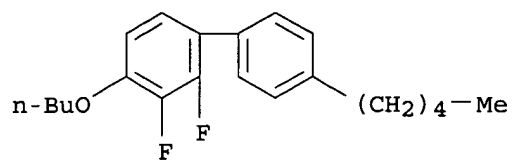
CMF C19 H22 F2 O



CM 4

CRN 157248-27-6

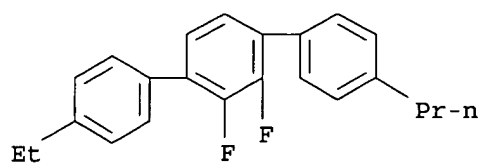
CMF C21 H26 F2 O



CM 5

CRN 157248-25-4

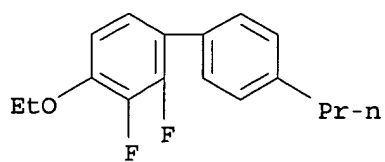
CMF C23 H22 F2



CM 6

CRN 157248-24-3

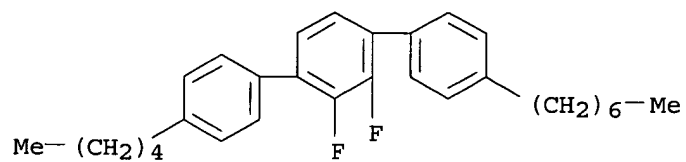
CMF C17 H18 F2 O



CM 7

CRN 121235-87-8

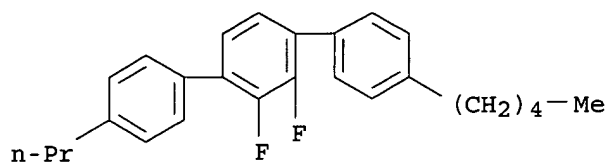
CMF C30 H36 F2



CM 8

CRN 121218-79-9

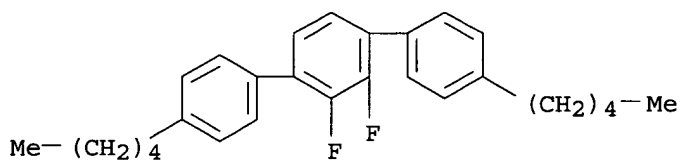
CMF C26 H28 F2



CM 9

CRN 121218-76-6

CMF C28 H32 F2



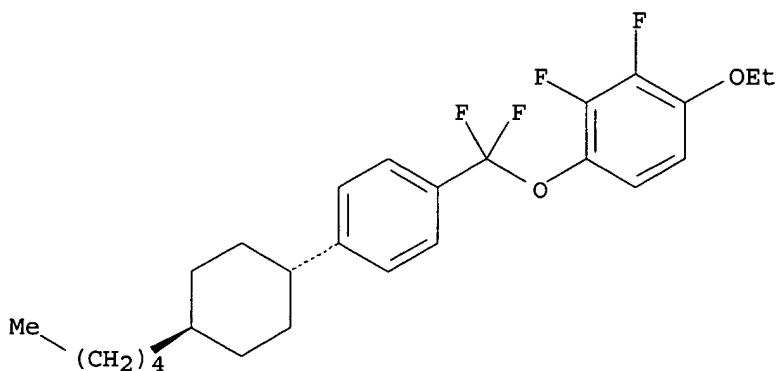
IT 197012-45-6P 197012-51-4P

RL: DEV (Device component use); SPN (Synthetic preparation); TEM (Technical or engineered material use); PREP (Preparation); USES (Uses) (prepn. of liq. crystal compds., liq. crystal compns. contg. the compds., and liq. crystal display devices made by using them)

RN 197012-45-6 CAPLUS

CN Benzene, 1-[difluoro[4-(trans-4-pentylcyclohexyl)phenyl]methoxy]-4-ethoxy-2,3-difluoro- (9CI) (CA INDEX NAME)

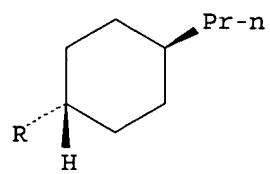
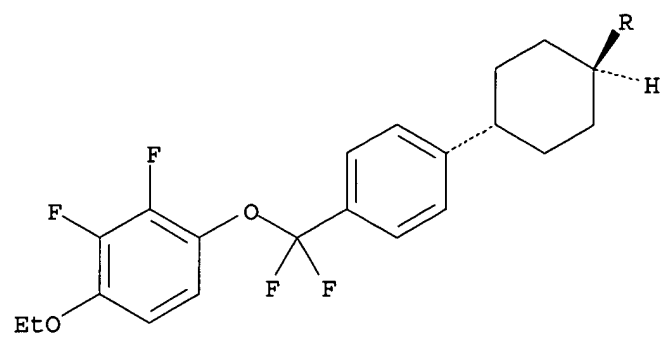
Relative stereochemistry.



RN 197012-51-4 CAPLUS

CN Benzene, 1-[difluoro[4-(4'-propyl[1,1'-bicyclohexyl]-4-yl)phenyl]methoxy]-4-ethoxy-2,3-difluoro-, [trans(trans)]- (9CI) (CA INDEX NAME)

Relative stereochemistry.



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L1US-6395353-\$.did. or JP-11029581-\$.did. or WO-9736847-\$.did.

3L2

6L1

END OF SEARCH HISTORY



US006395353B2

(12) **United States Patent**
Yanai et al.

(10) Patent No.: **US 6,395,353 B2**
(45) Date of Patent: **May 28, 2002**

(54) **LIQUID CRYSTAL COMPOSITION AND
LIQUID CRYSTAL DISPLAY ELEMENT**

(75) Inventors: **Motoki Yanai; Yasuhiro Kubo; Etsuo Nakagawa**, all of Ichihara (JP)

(73) Assignees: **Chisso Corporation, Osaka; Chisso Petrochemical Corporation, Tokyo**, both of (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/808,019**

(22) Filed: **Mar. 15, 2001**

(30) **Foreign Application Priority Data**

Mar. 15, 2000 (JP) 2000-072064

(51) Int. Cl.⁷ **C09K 19/30; C09K 19/20**

(52) U.S. Cl. **428/1.1; 252/299.63; 252/299.67**

(58) Field of Search **252/299.63, 299.67; 428/1.1**

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,993,690 A 11/1999 Kondo et al. 252/299.6

FOREIGN PATENT DOCUMENTS

EP	1114825	* 7/2001
JP	2001-31685	* 2/2001
JP	2001-31972	* 2/2001

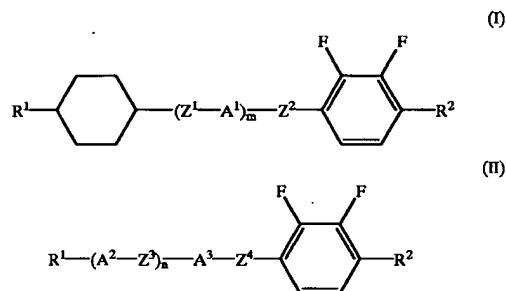
* cited by examiner

Primary Examiner—Shean C. Wu

(74) Attorney, Agent, or Firm—Wenderoth, Lind & Ponack, L.L.P.

(57) **ABSTRACT**

The present invention provides a liquid crystal composition comprising the compounds represented by the following formulas (I) and (II)



wherein each R¹ independently represents an alkyl group having 1–10 carbon atoms or an alkenyl group having 2–10 carbon atoms; each R² independently represents an alkyl or alkoxy group having 1–10 carbon atoms or an alkenyl group having 2–10 carbon atoms; Z¹ and Z² represent —CH₂SiH₂—, a single bond or —CH₂CH₂—, with the proviso that one of Z¹ and Z² represents —CH₂SiH₂— and the other represents a single bond or —CH₂CH₂—; A¹, A² and A³ each independently represent a ring including aromatic, alicyclic and heterocyclic groups; m and n are each independently 0 or 1; and Z³ and Z⁴ each independently represent a single bond, —CH₂CH₂—, —CF₂O— or —OCF₂—. The composition has a suitable Δn, a low viscosity, a largely negative Δε and a broad nematic liquid crystal phase range while satisfying various properties required for liquid crystal compositions for AM-LCD.

5 Claims, No Drawings

LIQUID CRYSTAL COMPOSITION AND LIQUID CRYSTAL DISPLAY ELEMENT

FIELD OF THE INVENTION

The present invention relates to a nematic liquid crystal composition having a negative dielectric anisotropy and to a liquid crystal display element containing the composition. More particularly, it relates to a liquid crystal composition having a negative dielectric anisotropy which is used for an active matrix liquid crystal display element, and to a liquid crystal display element containing the composition.

BACKGROUND OF THE INVENTION

A liquid crystal display (LCD) element consumes less electric power, and can be downsized and save weight as compared with a cathode ray tube (CRT) display. Therefore, several kinds of liquid crystal display systems such as twist nematic (TN), super twist nematic (STN) and thin film transistor (TFT) modes have been put to practical use. Among them, an active matrix liquid crystal display element (AM-LCD) has been the focus of interest as the most expected system because of its advanced colorization and minuteness.

A liquid crystal composition used in AM-LCD is required to have the following properties:

- 1) high voltage holding ratio to maintain high contrast of the liquid crystal display element,
- 2) broad nematic phase range to cope with various environments,
- 3) suitable refractive anisotropy (Δn) in accordance with cell thickness, and
- 4) suitable threshold voltage in accordance with drive circuit.

A drive system of AM-LCD has mainly been TN mode in which twist angle of alignment of liquid crystal molecules between upper and lower electrode substrates is 90 degrees. However, it has a difficulty in applying for wide view displays because of the narrow view angle. Some modes for improving view angle have been proposed as follows:

a) IPS display mode in which a liquid crystal display element shows homogeneous alignment of liquid crystal molecules when voltage is unimpressed and the molecules rotate at an angle of 45 to 90 degrees within the same plane when voltage is impressed (R. Kiefer, B. Weber, F. Windscheid and G. Baur, In-Plane Switching of Nematic Liquid Crystals, JAPAN DISPLAY '92, p. 547; and

b) VA display mode in which a liquid crystal display element shows homeotropic alignment when voltage is unimpressed and then shows horizontal alignment in one direction when voltage is impressed (K. Ohmuro, S. Kataoka, T. Sasaki and Y. Koike, Development of Super-High-Image-Quality Vertical-Alignment-Mode LCD, SID 97 Digest, p. 845).

These display systems have characteristics of quick response and high contrast in addition to the wide view angle. Further, they have a remarkable characteristic that they can comprise a liquid crystal composition having a negative dielectric anisotropy ($\Delta\epsilon$).

These drive systems utilize an electrically controlled birefringence mode. A product ($\Delta n \cdot d$) of refractive anisotropy (Δn) and cell thickness (d) should be, for example, $\Delta n \cdot d \approx 0.275 \mu\text{m}$ so as to provide a suitable contrast. Accordingly, a Δn value should be 0.05 to 0.13 so as to obtain a cell thickness of 2 to 6 μm . Since response time is

proportioned to viscosity of a liquid crystal composition (hereinafter referred to as η), a liquid crystal composition is required to have a small η . Further, threshold voltage decreases as an absolute value of dielectric anisotropy (hereinafter referred to as $\Delta\epsilon$) increases, and therefore, a liquid crystal composition is required to have a largely negative $\Delta\epsilon$.

Such a liquid crystal composition has been studied for various purposes, but is always required to be much more improved.

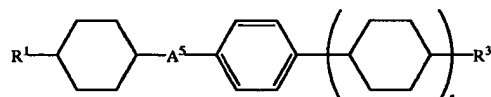
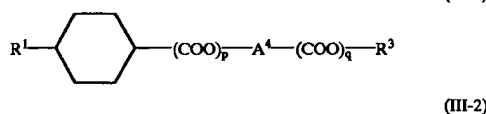
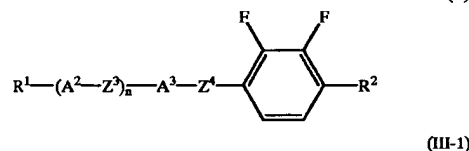
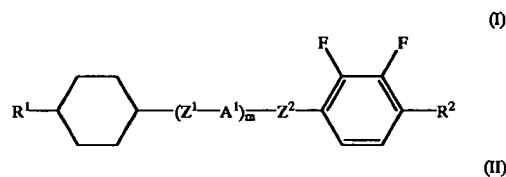
SUMMARY OF THE INVENTION

An object of the present invention is to provide a liquid crystal composition applicable for the display systems of the above a) and b), which can realize a wide view angle, a suitable Δn , and particularly a largely negative dielectric anisotropy, a broad range of nematic liquid crystal phase, a high voltage holding ratio and a low viscosity while satisfying various properties required for a liquid crystal composition for the AM-LCD.

The present inventors have studied liquid crystal compositions comprising various kinds of liquid crystalline compounds to solve the above problems, and found that the object can be achieved by a liquid crystal composition comprising several compounds as Components I to III, thus attaining the present invention.

The first liquid crystal composition of the present invention is described below in the items (1) and (2).

- (1) A liquid crystal composition comprising Component I selected from the group consisting of the compounds represented by formula (I), Component II selected from the group consisting of the compounds represented by formula (II) and Component III selected from the group consisting of the compounds represented by formulas (III-1) and (III-2)



wherein each R^1 independently represents an alkyl group having 1–10 carbon atoms or an alkenyl group having 2–10 carbon atoms; each R^2 independently represents an alkyl or alkoxy group having 1–10 carbon atoms, or an alkenyl group having 2–10 carbon atoms; Z^1 and Z^2 represent $-\text{CH}_2\text{SiH}_2-$, a single bond or $-\text{CH}_2\text{CH}_2-$, with the proviso that one of Z^1 and Z^2 represents $-\text{CH}_2\text{SiH}_2-$ and

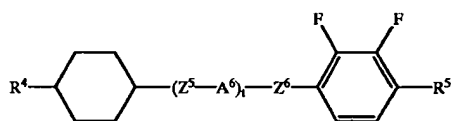
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the other represents a single bond or $-\text{CH}_2\text{CH}_2-$; ring A^1 represents a trans-1,4-cyclohexylene group, or a 1,4-phenylene group in which one or more hydrogen atoms may be substituted with fluorine atoms; m is 0 or 1, with the proviso that when m is 0, Z^2 represents $-\text{CH}_2\text{SiH}_2-$; Z^3 and Z^4 each independently represent a single bond, $-\text{CH}_2\text{CH}_2-$, $-\text{CF}_2\text{O}-$ or $-\text{OCF}_2-$; rings A^2 and A^3 represent a tetrahydropyran-2,5-diyl group, a trans-1,4-cyclohexylene group, a cyclohexa-1-ene-1,4-diyl group, or a 1,4-phenylene group in which one or more hydrogen atoms may be substituted with fluorine atoms; n is 0 or 1; with the proviso that when n=0 and Z^4 represents a single bond or $-\text{CH}_2\text{CH}_2-$, then ring A^3 represents a tetrahydropyran-2,5-diyl group; when n=0 and Z^4 represents $-\text{CF}_2\text{O}-$ or $-\text{OCF}_2-$, then ring A^3 represents a trans-1,4-cyclohexylene group or a cyclohexa-1-ene-1,4-diyl group; when n=1 and Z^3 and Z^4 each independently represent a single bond or $-\text{CH}_2\text{CH}_2-$, then one of rings A^2 and A^3 represents a tetrahydropyran-2,5-diyl group; when n=1 and Z^3 and/or Z^4 represent $-\text{CF}_2\text{O}-$ or $-\text{OCF}_2-$, then rings A^2 and A^3 represent a trans-1,4-cyclohexylene group, a cyclohexa-1-ene-1,4-diyl group, or a 1,4-phenylene group in which one or more hydrogen atoms may be substituted with fluorine atoms; each R^3 independently represents an alkyl group having 1–10 carbon atoms or an alkenyl group having 2–10 carbon atoms, in which one $-\text{CH}_2-$ may be substituted with $-\text{O}-$; ring A^4 represents a 1,4-phenylene group or a trans-1,4-cyclohexylene group; ring A^5 represents a trans-1,4-cyclohexylene group, or a 1,4-phenylene group in which one or more hydrogen atoms may be substituted with fluorine atoms; p, q and s are each independently 0 or 1 with the proviso that (p+q) is 0 or 1.

(2) A liquid crystal composition as described in the above item (1), which comprises 3–80% by weight of Component I, 3–80% by weight of Component II and 1–80% by weight of Component III.

The second liquid crystal composition of the present invention is described below in the item (3).

(3) A liquid crystal composition as described in the above item (1) or (2), which further comprises Component IV selected from the group consisting of the compounds represented by formula (IV)



wherein R^4 represents an alkyl group having 1–10 carbon atoms or an alkenyl group having 2–10 carbon atoms, R^5 represents an alkyl or alkoxy group having 1–10 carbon atoms or an alkenyl group having 2–10 carbon atoms, Z^5 and Z^6 each independently represent a single bond or $-\text{CH}_2\text{CH}_2-$, ring A^6 represents a 1,4-phenylene group or a trans-1,4-cyclohexylene group, and t is 0 or 1.

The third liquid crystal composition of the present invention is described below in the item (4).

(4) A liquid crystal composition as described in any one of the items (1) to (3), wherein the clearing point (Tc) is 60 to 100°C ., the refractive anisotropy (Δn) is 0.06 to 0.12 and the dielectric anisotropy ($\Delta\epsilon$) is -6 to -1 .

The liquid crystal display element of the present invention is described below in the item (5).

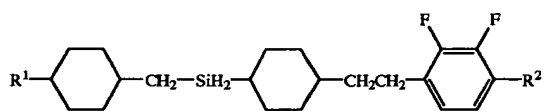
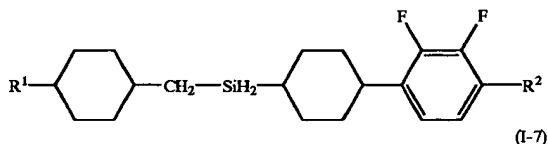
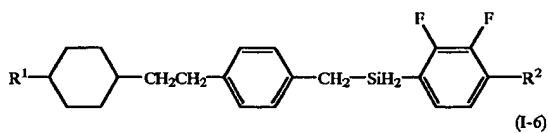
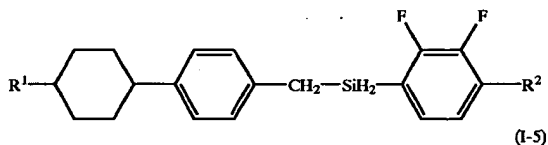
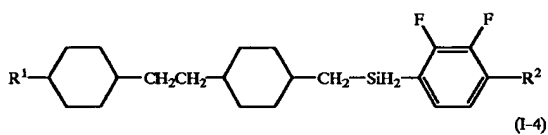
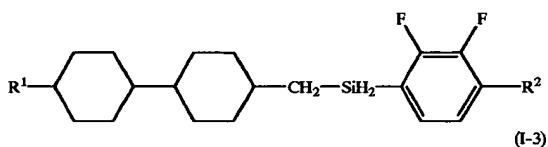
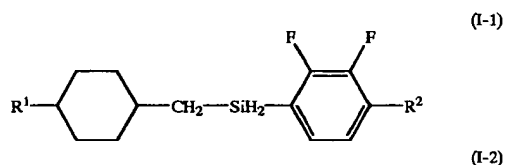
(5) A liquid crystal display element containing the liquid crystal composition as described in any one of the items (1) to (4).

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DETAILED DESCRIPTION OF THE INVENTION

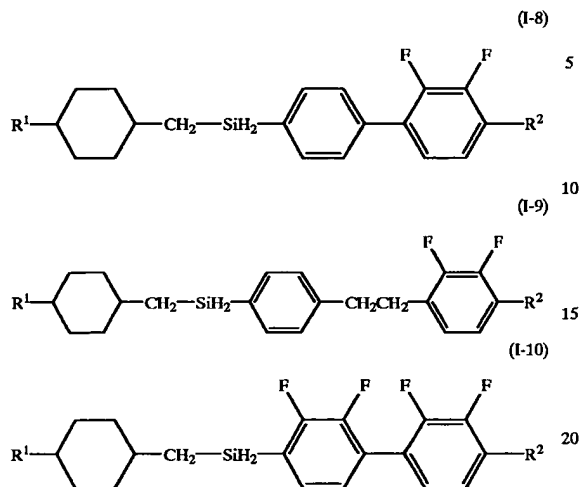
Component I of the liquid crystal composition according to the present invention comprises the compounds represented by formula (I), wherein the clearing point (Tc) is in the range of -50 to 100°C ., the refractive anisotropy (Δn) is in the range of 0.05 to 0.170, and the dielectric anisotropy ($\Delta\epsilon$) is in the range of -6 to -3 . It is superior in heat stability and chemical stability, and plays a role of decreasing the threshold voltage of a liquid crystal composition for TFT which requires high reliability. However, when a composition having a negative $\Delta\epsilon$ is prepared only from Component I, the composition may not have a high clearing point (Tc) or a suitable Δn , and compatibility of the composition at low temperature may be lowered.

Among the compounds represented by formula (I) as Component I, the following compounds are preferable. In the formulas, R^1 and R^2 each have the same meaning as defined above.



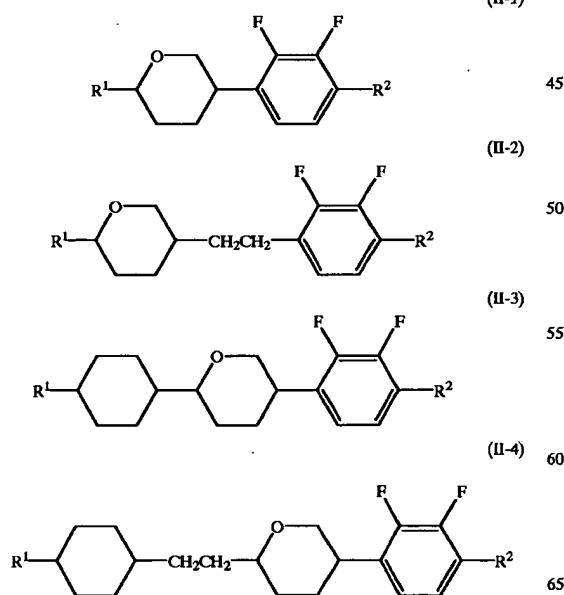
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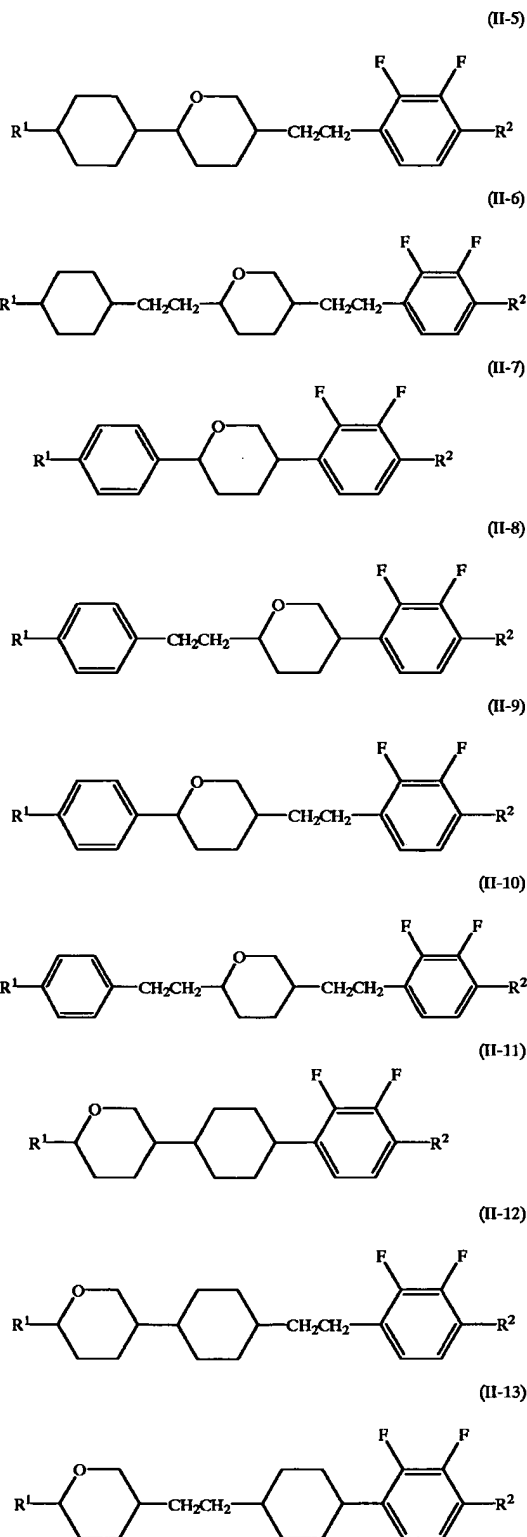
Component II comprises the compounds represented by formula (II), wherein the clearing point (T_c) is in the range of -20 to 160°C ., the refractive anisotropy (Δn) is in the range of 0.05 to 0.170 , and the dielectric anisotropy ($\Delta\epsilon$) is in the range of -7 to -3 . It is superior in heat stability and chemical stability, and plays a role of decreasing the threshold voltage of a liquid crystal composition for TFT which requires high reliability. However, when a composition having a negative $\Delta\epsilon$ is prepared only from Component II, compatibility of the composition at low temperature may be unfavorably lowered.

Among the compounds represented by formula (II) as Component II, the following compounds are preferable. In the formulas, R^1 and R^2 each have the same meaning as defined above.



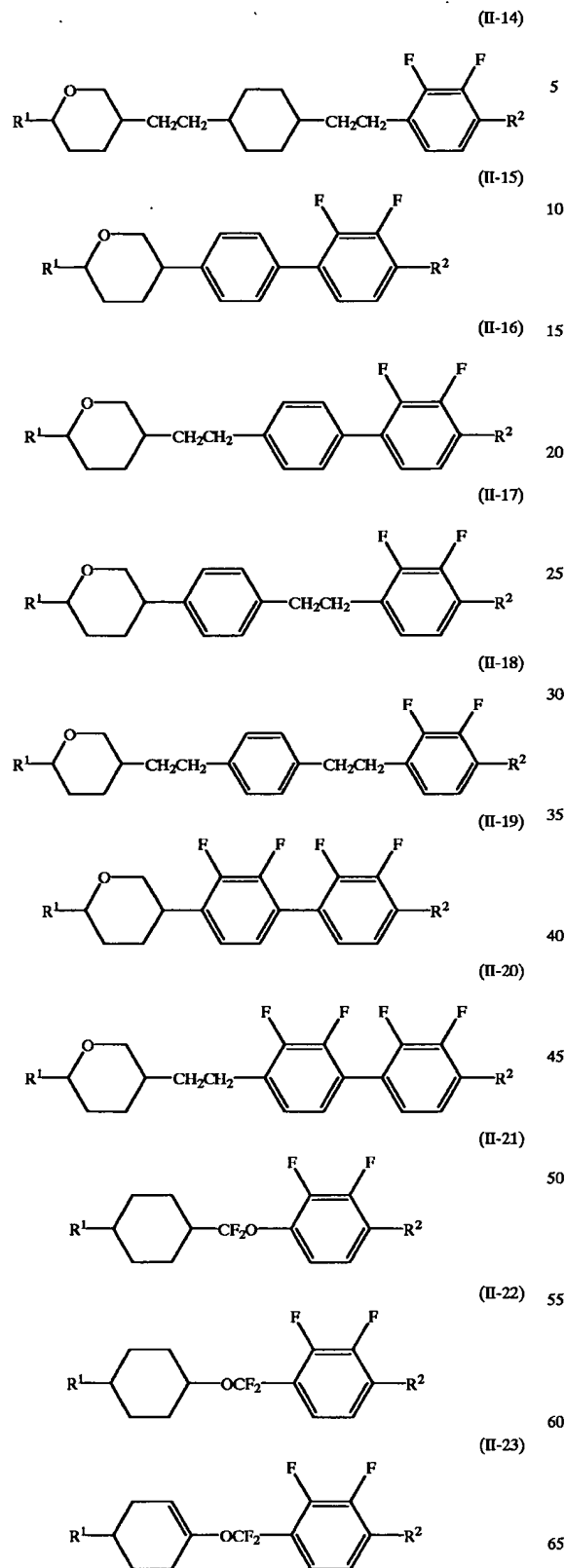
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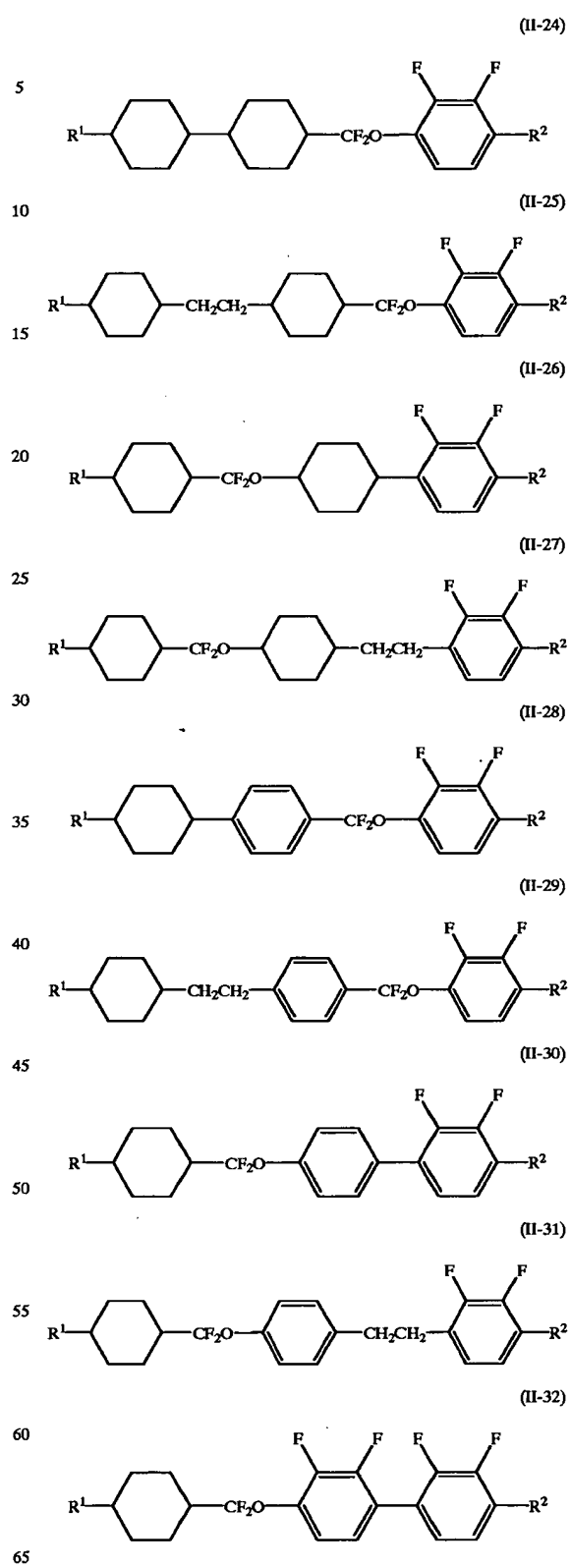
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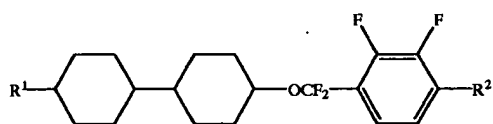
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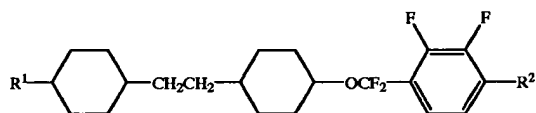
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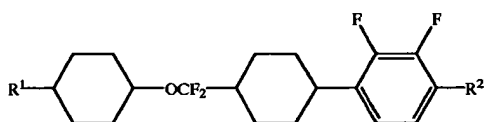
(II-33)



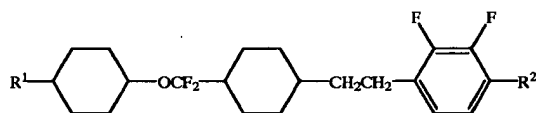
(II-34)



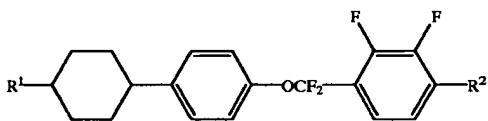
(II-35)



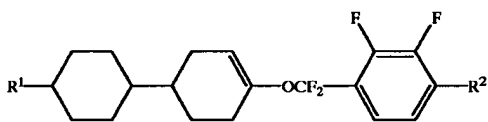
(II-36)



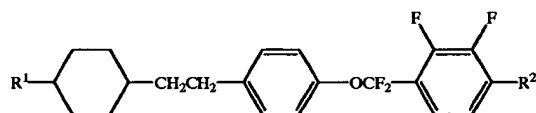
(II-37)



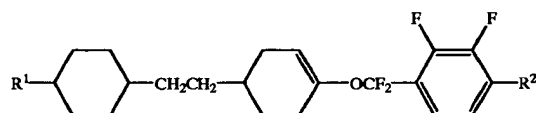
(II-38)



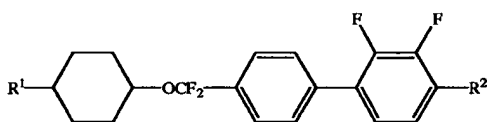
(II-39)



(II-40)



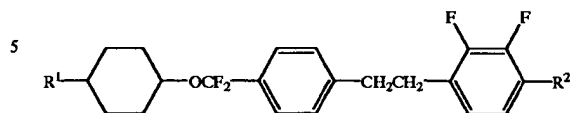
(II-41)



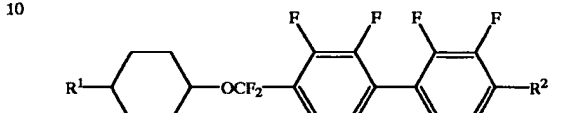
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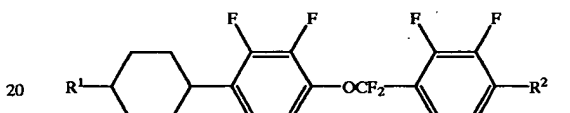
(II-42)



(II-43)



(II-44)



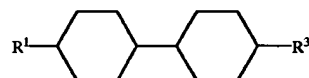
Component III comprises the compounds represented by formulas (III-1) and (III-2).

The compound represented by formula (III-1) has a clearing point (T_c) of 20 to 80° C., a refractive anisotropy (Δn) of 0.01 to 0.08 and a dielectric anisotropy ($\Delta\epsilon$) of approx. -1 to 0 as well as a low viscosity. It is superior in heat stability, chemical stability and compatibility, and plays a role of reducing Δn and viscosity, and adjusting $\Delta\epsilon$ of the composition.

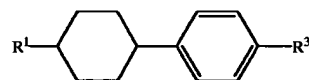
The compound represented by formula (III-2) has a clearing point (T_c) of 140 to 260° C., a refractive anisotropy (Δn) of 0.10 to 0.20 and a dielectric anisotropy ($\Delta\epsilon$) of approx. 0. It is superior in heat stability, chemical stability and compatibility, and plays a role of adjusting $\Delta\epsilon$ as well as elevating the clearing point (T_c) of the composition. That is, Component III can provide a composition having a well-adjusted clearing point (T_c), refractive anisotropy (Δn) and dielectric anisotropy ($\Delta\epsilon$), as well as a low viscosity and an excellent compatibility at low temperature.

Among the compounds represented by formulas (III-1) and (III-2) as Component III, the following compounds are preferable. In the formulas, R^1 and R^2 each have the same meaning as defined above.

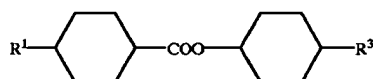
(III-1-1)



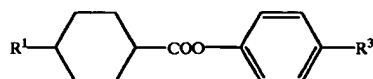
(III-1-2)



(III-1-3)

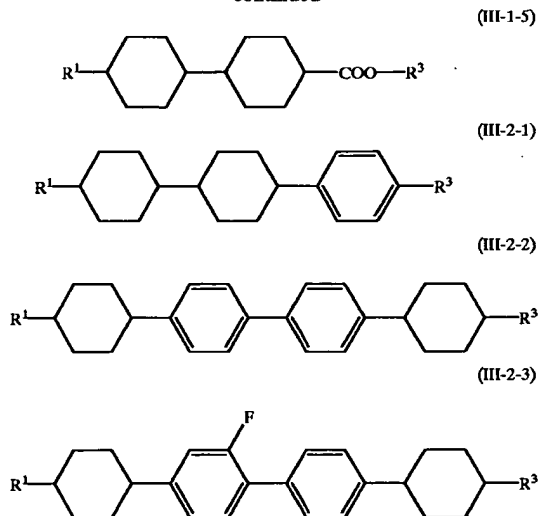


(III-1-4)



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Any combination of several kinds of compounds selected from Components I, II and III, respectively, can provide a liquid crystal composition for AM-LCD having a suitable Δn , a low viscosity, a largely negative dielectric anisotropy, a broad nematic liquid crystal phase range and a high voltage holding ratio (VHR). Further, it can provide a composition having a clearing point (T_c) of 60 to 100° C., a refractive anisotropy (Δn) of 0.06 to 0.12, a dielectric anisotropy ($\Delta\epsilon$) of -6 to -1, a low viscosity and a broad nematic liquid crystal phase range.

Component IV comprises the compounds represented by formula (IV), which has a clearing point (T_c) of -20 to 180° C., a refractive anisotropy (Δn) of 0.06 to 0.21 and a dielectric anisotropy ($\Delta\epsilon$) of approx. -7 to -3. It is superior in heat stability and chemical stability, and plays a role of decreasing threshold voltage of a liquid crystal composition for TFT which requires high reliability.

Any combination of several kinds of compounds selected from Components I to IV, respectively, can provide the present liquid crystal composition for AM-LCD having a suitable Δn , a largely negative dielectric anisotropy, a low viscosity, a broad nematic liquid crystal phase range and a high voltage holding ratio (VHR).

In the liquid crystal composition of the present invention, the amount of Component I is preferably from 3 to 80% by weight. More preferably it is 5 to 75% by weight. If the amount is less than 3% by weight, the liquid crystal composition may unfavorably have the small absolute value of $\Delta\epsilon$ (negative value) and the elevated threshold voltage. If the amount is more than 80% by weight, the compatibility at low temperature may unfavorably be lowered.

The amount of Component II is preferably from 3 to 80% by weight. More preferably it is 5 to 75% by weight. If the amount is less than 3% by weight, the liquid crystal composition may unfavorably have the small absolute value of $\Delta\epsilon$ (negative value). If the amount is more than 80% by weight, the compatibility at low temperature may unfavorably be lowered.

The amount of Component III is preferably 80% by weight or less. If the amount is more than 80% by weight, the liquid crystal composition may unfavorably have the small absolute value of $\Delta\epsilon$ (negative value) and the elevated threshold voltage.

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The compounds contained as components in the liquid crystal composition of the present invention can be synthesized by the methods described in the following references.

Regarding the compounds represented by formula (III-1) as Component III, JP-A 59-70624 and JP-A 60-16940 describe methods for preparation of the compounds represented by formula (III-1-1), and JP-A 54-27546 describes a method for preparation of the compounds represented by formula (III-1-4), respectively.

Regarding the compounds represented by formula (III-2) as Component III, JP-A 57-165328 describes a method for preparation of the compounds represented by formula in (III-2-1).

Regarding the compounds represented by formula (II) as Component II, the compounds having a pyran ring represented by formulas (II-1) to (II-20) can be prepared by hydrosilylation (G. A. Kraus et al., J. Org. Chem., 46, 2417 (1981), G. A. Kraus et al., J. Chem. Soc., Chem. Commun., 1568, (1986)) of the compounds obtained from aldehyde derivatives and bromoacetic esters by Reformatsky reaction (M. W. RATHKE et al., J. O. C., 35 (11), 3966 (1970), J. F. RUPPERT et al., J. O. C., 39(2), 269 (1974)), the method of P. PICARD et al. (Synthesis, 550 (1981)), the method of Yamaguchi et al. (Tetrahedron Lett., 25(11), 1159 (1984)) and the like.

Regarding the compounds represented by formulas (II-21) to (II-43), the compounds represented by formulas (II-22), (II-23) and (II-33) to (II-43) which have $-\text{OCF}_2-$ as a connecting group can be obtained by reacting carboxylic acid derivatives with phenols or alcohols, carrying out condensation reaction by dehydration to synthesize compounds having an ester group as a connecting group, and then reacting the resultant ester derivatives with a publicly known sulfurization agent such as Lawson's reagent to synthesize compounds having a thiocarbonyl group, followed by fluorinating the compounds using fluorinating agents such as hydrogen fluoride pyridine (M. Kuroboshi et al., Chem. Lett., 827, 1992) and diethylaminosulfur trifluoride (William H. Bunnelle et al., J. Org. Chem. 1990, 55, 768).

The compounds represented by formulas (II-21), (II-24) to (II-32) can be similarly synthesized.

JP-A 6-228037 describes a method for preparation of the compounds represented by formula (IV) as Component IV.

The compounds represented by formula (I) as Component I can be synthesized by the same procedure as the compounds represented by formula (IV), and a preparation method of compounds having a silicon bond between rings is described in WO 97/05144. Thus, each of the compounds as the component of the present liquid crystal composition can be synthesized according to the prior art.

The liquid crystal compositions of the present invention can be prepared by conventional methods per se. Typically, various components are mixed and dissolved with each other at high temperature.

The liquid crystal compositions of the present invention can also be used for guest-host (GH) mode displays with the addition of dichromatic dyes such as merocyanine, styryl, azo, azomethine, azoxy, quinophthalone, anthraquinone and tetrazine. The liquid crystal compositions of the present invention can also be used for NCAP which is produced by microencapsulating nematic liquid crystals, or polymer dispersed liquid crystal display (PDLCD) element which is typified by the polymer network liquid crystal display (PNLCD) element in which a three-dimensional matrix is formed in liquid crystals. The compositions can also be used

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with the addition of at least one chiral compound. In addition, the compositions can also be used for electrically controlled birefringence (ECB) mode or dynamic scattering (DS) mode displays.

The present invention will be described in detail by the following examples, but not limited thereto. In examples and comparative examples, all the composition ratios are indicated in terms of percentage by weight and the compounds used are represented by symbols as defined in Table 1. Property data of the liquid crystal compositions are shown in terms of clearing point (T_c), lower temperature limit of the nematic liquid crystal phase (T_L), refractive anisotropy at 25° C. (Δn), dielectric anisotropy at 25° C. ($\Delta\epsilon$), viscosity at

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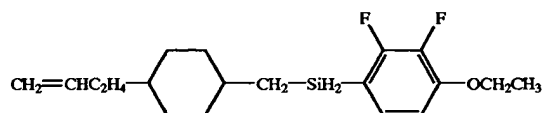
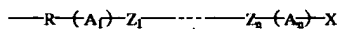
20° C. (η_{20}) and voltage holding ratio at 25° C. and 80° C. (VHR(25° C.) and VHR(80° C.)). T_L was determined by the liquid crystal phase after the composition was allowed to stand for 30 days in the respective freezers at 0° C., -10° C., -20° C., -30° C. and -40° C. $\Delta\epsilon(=\epsilon_{PA}-\epsilon_{PE})$ is obtained by measuring ϵ_{PA} (dielectric constant in the direction parallel to symmetrical axis) and ϵ_{PE} (dielectric constant in the direction perpendicular to symmetrical axis) using homeotropically aligned cells and homogeneously aligned cells. Voltage holding ratios (VHR) at 25° C. and 80° C. were measured by an area method using TN cell, in which a holding period was 16.6 msec and PIA-5210 manufactured by Chisso Corporation was used as an aligning film.

TABLE 1

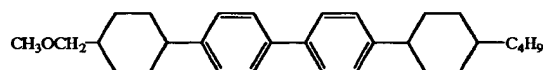
Method for Designating Compounds by Using Symbols			
$\text{---R---(A}_1\text{)---Z}_1\text{---} \cdots \cdots \text{---Z}_n\text{---(A}_n\text{)---X}$			
1) Left Terminal Group R—	Symbol	3) Bonding Group —Z ₁ —, —Z _n —	Symbol
$\text{C}_n\text{H}_{2n+1}\text{---}$	n—	$\text{---CH}_2\text{---}$	1
$\text{C}_n\text{H}_{2n+1}\text{OC}_m\text{H}_{2m}\text{---}$	nOm—	$\text{---SiH}_2\text{---}$	Si
$\text{CH}_2=\text{CH---}$	V—	$\text{---C}_2\text{H}_4\text{---}$	2
$\text{CH}_2=\text{CHC}_n\text{H}_{2n}\text{---}$	Vn—	---COO---	E
$\text{C}_n\text{H}_{2n+1}\text{CH=CHC}_m\text{H}_{2m}\text{---}$	nVm—	$\text{---CF}_2\text{O---}$	CF2O
		$\text{---OCF}_2\text{---}$	OCF2
2) Ring Structure —(A ₁)—, —(A _n)—	Symbol	4) Right Terminal Group—X	Symbol
	H	$\text{---C}_n\text{H}_{2n+1}$	-n
	B	$\text{---OC}_n\text{H}_{2n+1}$	—On
	B(F)	---COOCH_3	—EMe
	B(2F,3F)	$\text{---C}_n\text{H}_{2n}\text{OC}_m\text{H}_{2m+1}$	-nOm
	Dh		
	Ch		
5) Examples of Designation			
Example 1: V2-H1SIB(2F,3F)-O2			

TABLE 1-continued

Method for Designating Compounds by Using Symbols



Example 2: 1O1-HBBH-4



JP-A 6-228037 discloses an example of compounds having a negative $\Delta\epsilon$ and compositions comprising them. Compositions A and C, which were disclosed in Examples 26 and 27 of the gazette, respectively, were prepared to measure the above physical properties.

Comparative Example 1 (Composition A)

3-HBB(2F,3F)-1O1	10.0%
ZLI-1132	90.0%

(Commercially available liquid crystal compound produced by Merck)

T_c=74.9° C.T_L<-20° C. $\Delta n=0.139$ $\Delta\epsilon=9.7$ $\eta_{20}=29.2$ mPa·s

VHR(25° C.)=95.8%

VHR(80° C.)=48.5%

The composition of Comparative Example 1 has a positive $\Delta\epsilon$ and a remarkably low voltage holding ratio (VHR).

Comparative Example 2 (Composition C)

5-HBB(2F,3F)-1O1	10.0%
ZLI-1132	90.0%

T_c=77.0° C.T_L<-20° C. $\Delta n=0.133$ $\Delta\epsilon=9.7$ $\eta_{20}=29.1$ mPa·s

VHR(25° C.)=96.1%

VHR(80° C.)=48.7%

The composition of Comparative Example 2 has a positive $\Delta\epsilon$ and a remarkably low voltage holding ratio (VHR).

Since the compositions of Comparative Examples 1 and 2 contain a large amount of compounds having a cyano group, the voltage holding ratio (VHR) of the composition becomes so small that the composition cannot apply for AM-LCD, and $\Delta\epsilon$ is a positive value.

EXAMPLE 1

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	6.0%
5-H1SiB(2F,3F)-O2	5.0%
3-HH1SiB(2F,3F)-1	5.0%
2-HH1SiB(2F,3F)-O2	12.0%
3-HH1SiB(2F,3F)-O2	9.0%
3-HH1SiB(2F,3F)-O3	5.0%
3-HB1SiB(2F,3F)-O2	3.0%
Component II	
3-DhB(2F,3F)-O2	5.0%
3-HDhB(2F,3F)-O2	10.0%
5-HDhB(2F,3F)-O2	10.0%
5-HHCF2OB(2F,3F)-O2	10.0%
3-HHOCF2B(2F,3F)-O1	5.0%
3-HB(2F,3F)OCF2B(2F,3F)-O1	5.0%
Component III	
3-HH-4	4.0%
3-HB-O2	3.0%
3-HH-EMe	3.0%

The composition had the following physical properties:

T_c=75.0° C.T_L<-20° C. $\Delta n=0.096$ $\Delta\epsilon=-4.6$ $\eta_{20}=37.8$ mPa·s

VHR(25° C.)=99.1%

VHR(80° C.)=98.1%

The composition of Example 1 has an especially largely negative $\Delta\epsilon$ and a very large voltage holding ratio (VHR) as compared with those of Comparative Examples 1 and 2. Accordingly, it is suitable for the display systems of the above a) and b).

EXAMPLE 2

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	12.0%
5-H1SiB(2F,3F)-O2	12.0%
2-HH1SiB(2F,3F)-O2	15.0%
3-HH1SiB(2F,3F)-O2	13.0%
3-HH1SiB(2F,3F)-O3	13.0%
3-H1SiHB(2F,3F)-O2	3.0%
3-H1SiBB(2F,3F)-O2	3.0%
Component II	
3-HDhB(2F,3F)-O2	4.0%
5-HDhB(2F,3F)-O2	4.0%
3-BDhB(2F,3F)-O2	3.0%
Component III	
3-HB-O2	4.0%
3-HHB-1	8.0%
3-HHB-O1	6.0%

The composition had the following physical properties:

$T_c=60.1^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

$\Delta n=0.098$

$\Delta\epsilon=-3.6$

$\eta_{20}=31.0\text{ mPa}\cdot\text{s}$

VHR(25°C .)=99.2%

VHR(80°C .)=98.4%

EXAMPLE 3

The composition comprising the following components was prepared.

Component I	
V-H1SiB(2F,3F)-O2	3.0%
3-H1SiB(2F,3F)-O2	9.0%
5-H1SiB(2F,3F)-O2	12.0%
3-HH1SiB(2F,3F)-1	5.0%
2-HH1SiB(2F,3F)-O2	15.0%
3-HH1SiB(2F,3F)-O2	10.0%
3-HH1SiB(2F,3F)-O3	15.0%
3-H2H1SiB(2F,3F)-O2	5.0%
Component II	
5-HHCF2OB(2F,3F)-O2	6.0%
5-HBCF2OB(2F,3F)-O2	5.0%
Component III	
3-HB-O2	4.0%
3-HHB-O1	3.0%
1O1-HBBH-4	4.0%
3-HBBH-3	4.0%

The composition had the following physical properties:

$T_c=65.5^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

$\Delta n=0.101$

$\Delta\epsilon=-3.5$

$\eta_{20}=32.0\text{ mPa}\cdot\text{s}$

VHR(25°C .)=99.0%

VHR(80°C .)=98.4%

EXAMPLE 4

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	9.0%
5-H1SiB(2F,3F)-O2	9.0%
3-HH1SiB(2F,3F)-1	6.0%
2-HH1SiB(2F,3F)-O2	15.0%
3-HH1SiB(2F,3F)-O2	13.0%
3-HH1SiB(2F,3F)-O3	13.0%
3-HB1SiB(2F,3F)-O2	3.0%
3-H1SiBB(2F,3F)-O2	3.0%
Component II	
3-BDhB(2F,3F)-O2	6.0%
5-HHCF2OB(2F,3F)-O2	3.0%
5-HBCF2OB(2F,3F)-O2	3.0%
3-HB(2F,3F)OCF2B(2F,3F)-O1	4.0%
Component III	
3-HB-O2	5.0%
3-HHB-3	8.0%

20

The composition had the following physical properties:

$T_c=60.2^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

25

$\Delta n=0.100$

$\Delta\epsilon=-3.9$

$\eta_{20}=30.0\text{ mPa}\cdot\text{s}$

VHR(25°C .)=99.2%

30

VHR(80°C .)=98.0%

EXAMPLE 5

The composition comprising the following components was prepared.

35

Component I	
3-H1SiB(2F,3F)-O2	6.0%
2-HH1SiB(2F,3F)-O2	3.0%
3-HH1SiB(2F,3F)-O2	3.0%
Component II	
3-DhB(2F,3F)-O2	7.0%
3-Dh2B(2F,3F)-O2	3.0%
3-HDhB(2F,3F)-O2	10.0%
5-HDhB(2F,3F)-O2	10.0%
3-H2DhB(2F,3F)-O2	5.0%
3-BDhB(2F,3F)-O2	16.0%
5-BDhB(2F,3F)-O2	16.0%
3-DhHB(2F,3F)-O2	5.0%
Component III	
3-HH-4	3.0%
1O1-HH-3	3.0%
3-HB-O2	3.0%
3-HB-O4	4.0%
3-HEH-5	3.0%

55

The composition had the following physical properties:

$T_c=75.5^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

60

$\Delta n=0.102$

$\Delta\epsilon=-4.7$

$\eta_{20}=40.7\text{ mPa}\cdot\text{s}$

65

EXAMPLE 6

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	6.0%
2-HH1SiB(2F,3F)-1	4.0%
3-HH1SiB(2F,3F)-O2	4.0%
Component II	
3-HCF2OB(2F,3F)-O2	3.0%
3-HOCF2B(2F,3F)-O2	3.0%
3-ChOCF2B(2F,3F)-O2	3.0%
3-HHCF2OB(2F,3F)-O1	5.0%
5-HHCF2OB(2F,3F)-O2	9.0%
3-HBCF2OB(2F,3F)-O2	7.0%
5-HBCF2OB(2F,3F)-O2	7.0%
3-HChOCF2B(2F,3F)-O1	14.0%
3-HHOCF2B(2F,3F)-O1	4.0%
3-HBOCF2B(2F,3F)-O1	4.0%
3-HOCF2B(2F,3F)B(2F,3F)-O1	4.0%
Component III	
3-HH-4	5.0%
3-HB-O2	6.0%
3-HB-O4	4.0%
3-HH-EMe	4.0%
3-HHB-1	4.0%

The composition had the following physical properties:

$T_c=80.1^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

$\Delta n=0.094$

$\Delta\epsilon=-3.1$

$\eta_{20}=36.1\text{ mPa}\cdot\text{s}$

EXAMPLE 7

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	5.0%
2-HH1SiB(2F,3F)-O2	4.0%
Component II	
3-DhB(2F,3F)-O2	5.0%
3-HDhB(2F,3F)-O2	12.0%
5-HDhB(2F,3F)-O2	8.0%
3-BDhB(2F,3F)-O2	5.0%
5-BDhB(2F,3F)-O2	5.0%
3-DhB(2F,3F)B(2F,3F)-O2	4.0%
5-HHCF2OB(2F,3F)-O2	5.0%
5-HBCF2OB(2F,3F)-O2	6.0%
3-HCF2OHB(2F,3F)-O2	5.0%
3-HChOCF2B(2F,3F)-O1	5.0%
3-HCF2OBB(2F,3F)-O2	5.0%
3-HBOCF2B(2F,3F)-O1	5.0%
3-HB(2F,3F)OCF2B(2F,3F)-O1	5.0%
Component III	
3-HH-4	8.0%
3-HB-O2	4.0%
3-HH-EMe	4.0%

The composition had the following physical properties:

$T_c=94.0^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

$\Delta n=0.099$

$\Delta\epsilon=-4.5$

$\eta_{20}=42.0\text{ mPa}\cdot\text{s}$

EXAMPLE 8

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	5.0%
V2-H1SiB(2F,3F)-O2	5.0%
2-HH1SiB(2F,3F)-O2	7.0%
3-HH1SiB(2F,3F)-V	3.0%
3-HH1SiB(2F,3F)-O2	12.0%
3-HH1SiB(2F,3F)-O3	7.0%
1V2-HH1SiB(2F,3F)-O2	5.0%
Component II	
3-DhB(2F,3F)-O2	7.0%
3-HDhB(2F,3F)-O2	10.0%
V2-HDhB(2F,3F)-O2	5.0%
5-HDhB(2F,3F)-O2	15.0%
3-BDhB(2F,3F)-O2	4.0%
5-BDhB(2F,3F)-O2	4.0%
Component III	
3-HH-4	3.0%
3-HB-O2	4.0%
V-HHB-3	4.0%

The composition had the following physical properties:

$T_c=72.8^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

$\Delta n=0.104$

$\Delta\epsilon=-5.1$

$\eta_{20}=38.3\text{ mPa}\cdot\text{s}$

VHR(25°C .)=99.2%

VHR(80°C .)=98.0%

EXAMPLE 9

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	5.0%
5-H1SiB(2F,3F)-O2	5.0%
2-HH1SiB(2F,3F)-O2	10.0%
3-HH1SiB(2F,3F)-O2	12.0%
3-HH1SiB(2F,3F)-O3	12.0%
Component II	
3-HCF2OB(2F,3F)-O2	5.0%
5-HHCF2OB(2F,3F)-O2	12.0%
5-HBCF2OB(2F,3F)-O2	8.0%
3-HCF2OBB(2F,3F)-O2	4.0%
3-HChOCF2B(2F,3F)-O1	4.0%
3-HHOCF2B(2F,3F)-O1	4.0%
3-HB(2F,3F)OCF2B(2F,3F)-O2	8.0%
Component III	
V-HH-3	3.0%
3-HB-O2	4.0%
3-HH-EMe	4.0%

The composition had the following physical properties:

$T_c=75.3^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

$\Delta n=0.098$

$\Delta\epsilon=-3.9$

$\eta_{20}=37.6\text{ mPa}\cdot\text{s}$

VHR(25°C .)=99.0%

VHR(80°C .)=98.3%

EXAMPLE 10

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	8.0%
5-H1SiB(2F,3F)-O2	8.0%
2-HH1SiB(2F,3F)-O2	10.0%
3-HH1SiB(2F,3F)-O2	12.0%
3-HH1SiB(2F,3F)-O3	10.0%
Component II	
3-DhB(2F,3F)-O2	5.0%
5-DhB(2F,3F)-O2	5.0%
Component III	
3-HH-4	4.0%
3-HEH-5	4.0%
3-HB-O2	8.0%
3-HEB-O3	4.0%
4-HEB-O1	4.0%
1O1-HBBH-4	6.0%
1O1-HBBH-5	6.0%
3-HBBH-3	3.0%
3-HBB(F)H-3	3.0%

The composition had the following physical properties:

$T_c=84.3^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

$\Delta n=0.098$

$\Delta\epsilon=-2.9$

$\eta_{20}=30.0\text{ mPa}\cdot\text{s}$

EXAMPLE 11

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	5.0%
5-H1SiB(2F,3F)-O2	5.0%
2-HH1SiB(2F,3F)-O2	15.0%
3-HH1SiB(2F,3F)-O2	15.0%
3-HH1SiB(2F,3F)-O3	14.0%
3-H2H1SiB(2F,3F)-O2	5.0%
3-H1SiHB(2F,3F)-O2	5.0%
Component II	
3-HHCF2OB(2F,3F)-1	4.0%
3-HHCF2OB(2F,3F)-O2	6.0%
5-HHCF2OB(2F,3F)-O2	5.0%
Component III	
3-HB-O2	10.0%
3-HB-O4	4.0%
3-HEH-3	4.0%
3-HHB-1	3.0%

The composition had the following physical properties:

$T_c=68.7^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

$\Delta n=0.094$

$\Delta\epsilon=-3.6$

$\eta_{20}=26.0\text{ mPa}\cdot\text{s}$

EXAMPLE 12

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	8.0%
5-H1SiB(2F,3F)-O2	8.0%
2-HH1SiB(2F,3F)-O2	10.0%
3-HH1SiB(2F,3F)-O2	12.0%
3-HH1SiB(2F,3F)-O3	6.0%
3-HB1SiB(2F,3F)-O2	4.0%
Component II	
3-HDhB(2F,3F)-O2	3.0%
3-BDhB(2F,3F)-O2	3.0%
5-HHCF2OB(2F,3F)-O2	3.0%
5-HBCF2OB(2F,3F)-O2	3.0%
Component III	
3-HB-O2	10.0%
3-HH-EMe	4.0%
3-HEB-O3	4.0%
4-HEB-O1	4.0%
3-HHB-3	4.0%
1O1-HBBH-4	7.0%
The other component	
3-HHEBH-3	4.0%
3-HHEBH-5	3.0%

25

The composition had the following physical properties:

$T_c=80.1^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

$\Delta n=0.098$

$\Delta\epsilon=-2.6$

$\eta_{20}=30.1\text{ mPa}\cdot\text{s}$

30

EXAMPLE 13

The composition comprising the following components was prepared.

35

Component I	
3-H1SiB(2F,3F)-O2	5.0%
3-HH1SiB(2F,3F)-O2	5.0%
Component II	
3-DhB(2F,3F)-O2	7.0%
3-HDhB(2F,3F)-O2	15.0%
5-HDhB(2F,3F)-O2	15.0%
3-BDhB(2F,3F)-O2	10.0%
Component III	
2-HH-3	5.0%
3-HH-4	5.0%
3-HB-O2	4.0%
3-HB-O4	5.0%
3-HEH-3	4.0%
3-HH-EMe	4.0%
3-HBBH-3	4.0%
3-HBB(F)H-5	4.0%
The other component	
3-HHEH-3	8.0%

55

The composition had the following physical properties:

$T_c=91.5^\circ\text{C}$.

$T_L<-20^\circ\text{C}$.

$\Delta n=0.089$

$\Delta\epsilon=-3.5$

$\eta_{20}=32.7\text{ mPa}\cdot\text{s}$

60

EXAMPLE 14

The composition comprising the following components was prepared.

65

Component I	
3-H1SiB(2F,3F)-O2	6.0%
2-HH1SiB(2F,3F)-O2	6.0%
Component II	
3-HCF2OB(2F,3F)-O2	5.0%
3-HOCF2B(2F,3F)-O2	5.0%
5-HHCF2OB(2F,3F)-O2	10.0%
3-HCF2OHB(2F,3F)-O2	5.0%
5-HBCF2OB(2F,3F)-O2	15.0%
5-HChOCF2E(2F,3F)-O1	5.0%
3-HBOCF2B(2F,3F)-O1	5.0%
Component III	
3-HH-4	12.0%
3-HB-O2	12.0%
3-HH-EMe	6.0%
3-HHB-3	8.0%

The composition had the following physical properties:

$T_c=76.8^\circ \text{C}$.

$T_L<-20^\circ \text{C}$.

$\Delta n=0.086$

$\Delta \epsilon=-2.6$

$\eta_{20}=32.26.8 \text{ mPa}\cdot\text{s}$

EXAMPLE 15

The composition comprising the following components was prepared.

Component I	
2-HH1SiB(2F,3F)-O2	5.0%
3-HH1SiB(2F,3F)-O2	6.0%
Component II	
3-HDhB(2F,3F)-O2	6.0%
5-HDhB(2F,3F)-O2	12.0%
3-DhH2B(2F,3F)-O2	6.0%
5-HHCF2OB(2F,3F)-O2	8.0%
5-HBCF2OB(2F,3F)-O2	8.0%
3-HChOCF2B(2F,3F)-O1	5.0%
3-HDOCF2B(2F,3F)-O1	5.0%
Component III	
3-HH-4	12.0%
V2-HH-4	5.0%
3-HB-O2	12.0%
2-HH-EMe	4.0%
3-HH-EMe	6.0%

The composition had the following physical properties:

$T_c=87.5^\circ \text{C}$.

$T_L<-20^\circ \text{C}$.

$\Delta n=0.087$

$\Delta \epsilon=-3.5$

$\eta_{20}=29.5 \text{ mPa}\cdot\text{s}$

EXAMPLE 16

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	5.0%
5-H1SiB(2F,3F)-O2	6.0%
2-HH1SiD(2F,3F)-O2	6.0%
3-HH1SiB(2F,3F)-O2	9.0%
3-HB1SiB(2F,3F)-O2	3.0%
3-H1SiHB(2F,3F)-O2	4.0%
Component II	
3-DhB(2F,3F)-O2	5.0%
3-HDhB(2F,3F)-O2	5.0%
V-HDhB(2F,3F)-O2	5.0%
5-HDhB(2F,3F)-O2	11.0%
3-BDhB(2F,3F)-O2	5.0%
Component III	
2-HH-3	5.0%
V-HH-5	10.0%
3-HB-O2	8.0%
3-HB-O4	4.0%
V-HHB-3	3.0%
1O1-HBBH-5	6.0%

The composition had the following physical properties:

$T_c=71.5^\circ \text{C}$.

$T_L<-20^\circ \text{C}$.

$\Delta n=0.095$

$\Delta \epsilon=-3.5$

$\eta_{20}=27.5 \text{ mPa}\cdot\text{s}$

EXAMPLE 17

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	5.0%
5-H1SiB(2F,3F)-O2	5.0%
2-HH1SiB(2F,3F)-O2	10.0%
3-HH1SiB(2F,3F)-O2	12.0%
Component II	
3-HCF2OB(2F,3F)-O2	8.0%
3-HOCF2B(2F,3F)-O2	8.0%
5-HHCF2OB(2F,3F)-O2	4.0%
3-HChOCF2B(2F,3F)-O1	5.0%
3-HB(2F,3F)OCF2B(2F,3F)-O1	5.0%
Component III	
2-HH-3	5.0%
3-HH-4	5.0%
3-HB-O2	8.0%
3-HB-O4	4.0%
3-HHB-3	5.0%
1O1-HBBH-5	6.0%
The other component	
3-HHEH-3	5.0%

The composition had the following physical properties:

$T_c=65.2^\circ \text{C}$.

$T_L<-20^\circ \text{C}$.

$\Delta n=0.084$

$\Delta \epsilon=-2.7$

$\eta_{20}=24.6 \text{ mPa}\cdot\text{s}$

EXAMPLE 18

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	5.0%
5-H1SiB(2F,3F)-O2	5.0%
2-HH1SiB(2F,3F)-O2	10.0%
3-HH1SiB(2F,3F)-O2	12.0%
Component II	
3-HDhB(2F,3F)-O2	8.0%
5-HDhB(2F,3F)-O2	8.0%
3-HOCF2B(2F,3F)-O2	8.0%
5-HHCF2OB(2F,3F)-O2	3.0%
5-HBCF2OB(2F,3F)-O2	5.0%
Component III	
2-HH-3	5.0%
3-HH-4	8.0%
3-HB-O2	8.0%
3-HEB-O3	4.0%
4-HEB-O1	4.0%
3-HHB-3	3.0%
101-HBBH-5	4.0%

The composition had the following physical properties:

$T_c=68.1^\circ \text{C}$.

$T_L<-20^\circ \text{C}$.

$\Delta n=0.086$

$\Delta \epsilon=-3.2$

$\eta_{20}=26.8 \text{ mPa}\cdot\text{s}$

EXAMPLE 19

The composition comprising the following components was prepared.

Component I	
2-HH1SiB(2F,3F)-O2	6.0%
3-HH1SiB(2F,3F)-O2	6.0%
Component II	
3-HDhB(2F,3F)-O2	6.0%
5-HDhB(2F,3F)-O2	6.0%
Component III	
2-HH-3	6.0%
3-HH-4	10.0%
3-HB-O2	16.0%
3-HB-O4	4.0%
2-HH-EMe	4.0%
3-HH-EMe	15.0%
3-HHB-1	8.0%
3-HHB-3	8.0%
3-HHB-O1	5.0%

The composition had the following physical properties:

$T_c=80.4^\circ \text{C}$.

$T_L<-20^\circ \text{C}$.

$\Delta n=0.077$

$\Delta \epsilon=-1.4$

$\eta_{20}=14.3 \text{ mPa}\cdot\text{s}$

EXAMPLE 20

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	7.0%
3-HH1SiB(2F,3F)-O2	7.0%
Component II	
5-HHCF2OB(2F,3F)-O2	6.0%
5-HBCF2OB(2F,3F)-O2	4.0%
5-HChOCF2B(2F,3F)-O1	5.0%
Component III	
3-HH-4	12.0%
3-HB-O2	16.0%
3-HB-O4	4.0%
2-HH-EMe	5.0%
3-HH-EMe	16.0%
3-HHB-1	8.0%
3-HHB-3	10.0%

The composition had the following physical properties:

$T_c=71.6^\circ \text{C}$.

$T_L<-20^\circ \text{C}$.

$\Delta n=0.077$

$\Delta \epsilon=-1.1$

$\eta_{20}=14.4 \text{ mPa}\cdot\text{s}$

EXAMPLE 21

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	7.0%
3-HH1SiB(2F,3F)-O2	5.0%
3-HH1SiB(2F,3F)-O3	5.0%
Component II	
5-HDhB(2F,3F)-O3	6.0%
3-HCF2OB(2F,3F)-O2	5.0%
5-HBCF2OB(2F,3F)-O2	5.0%
Component III	
3-HH-4	12.0%
3-HB-O2	16.0%
2-HH-EMe	5.0%
3-HH-EMe	16.0%
3-HHB-1	8.0%
3-HHB-3	10.0%

The composition had the following physical properties:

$T_c=68.3^\circ \text{C}$.

$T_L<-20^\circ \text{C}$.

$\Delta n=0.076$

$\Delta \epsilon=-1.4$

$\eta_{20} 32 \text{ } 15.3 \text{ mPa}\cdot\text{s}$

EXAMPLE 22

The composition comprising the following components was prepared.

Component I	
2-HH1SiB(2F,3F)-O2	10.0%
3-HH1SiB(2F,3F)-O2	7.0%
3-HB1SiB(2F,3F)-O2	3.0%
Component II	
3-DhB(2F,3F)-O2	5.0%
3-HDhB(2F,3F)-O2	10.0%
5-HDhB(2F,3F)-O2	10.0%
3-BDhB(2F,3F)-O2	5.0%
Component III	
3-HH-4	8.0%
3-HB-O2	8.0%
3-HH-EMe	5.0%
3-HHB-3	4.0%
3-HBBH-3	5.0%
Component IV	
3-HB(2F,3F)-O2	5.0%
5-HB(2F,3F)-O2	5.0%
3-HBB(2F,3F)-O2	5.0%
3-HHB(2F,3F)-O2	5.0%

The composition had the following physical properties:

$T_c=90.3^\circ \text{ C.}$

$T_L<-20^\circ \text{ C.}$

$\Delta n=0.100$

$\Delta \epsilon=-4.1$

$\eta_{20}=33.3 \text{ mPa}\cdot\text{s}$

EXAMPLE 23

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	6.0%
2-HH1SiB(2F,3F)-O2	6.0%
3-HH1SiB(2F,3F)-O2	6.0%
Component II	
3-HOCF2B(2F,3F)-O2	10.0%
5-HHCF2OB(2F,3F)-O2	10.0%
3-HChOCF2B(2F,3F)-O1	5.0%
Component III	
3-HH-4	8.0%
3-HH-EMe	5.0%
3-HHB-3	4.0%
Component IV	
3-HB(2F,3F)-O2	4.0%
3-H2B(2F,3F)-O2	4.0%
5-HB(2F,3F)-O2	8.0%
5-HBB(2F,3F)-3	4.0%
3-HBB(2F,3F)-O2	6.0%
3-H2BB(2F,3F)-O2	4.0%
3-HHB(2F,3F)-O2	6.0%
V-HHB(2F,3F)-O2	4.0%

The composition had the following physical properties:

$T_c=78.1^\circ \text{ C.}$

$T_L<-20^\circ \text{ C.}$

$\Delta n=0.100$

$\Delta \epsilon=-3.8$

$\eta_{20}=31.0 \text{ mPa}\cdot\text{s}$

EXAMPLE 24

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	5.0%
5-H1SiB(2F,3F)-O2	5.0%
2-HH1SiB(2F,3F)-O2	10.0%
3-HH1SiB(2F,3F)-O2	10.0%
Component II	
3-HDhB(2F,3F)-O2	5.0%
5-HDhB(2F,3F)-O2	5.0%
3-HHCF2OB(2F,3F)-O2	5.0%
3-HBCF2OB(2F,3F)-O2	5.0%
Component III	
2-HH-5	4.0%
3-HH-4	4.0%
3-HB-O2	4.0%
3-HB-O4	4.0%
3-HHB-3	4.0%
Component IV	
3-HB(2F,3F)-O2	5.0%
V-HB(2F,3F)-O2	5.0%
3-HBB(2F,3F)-O2	5.0%
V-HBB(2F,3F)-O2	5.0%
3-HHB(2F,3F)-O2	5.0%
5-HHB(2F,3F)-O2	5.0%

The composition had the following physical properties:

$T_c=79.0^\circ \text{ C.}$

$T_L<-20^\circ \text{ C.}$

$\Delta n=0.103$

$\Delta \epsilon=-4.1$

$\eta_{20}=28.5 \text{ mPa}\cdot\text{s}$

VHR(25° C.)=99.1%

VHR(80° C.)=97.9%

EXAMPLE 25

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	9.0%
5-H1SiB(2F,3F)-O2	8.0%
3-HH1SiB(2F,3F)-O2	12.0%
5-HH1SiB(2F,3F)-O2	6.0%
3-HH1SiB(2F,3F)-O3	12.0%
Component II	
3-HBOCF2B(2F,3F)-O2	16.0%
5-HBOCF2B(2F,3F)-O2	16.0%
Component III	
3-HH-4	11.0%
3-HB-O2	10.0%

The composition had the following physical properties:

$T_c=62.3^\circ \text{ C.}$

$T_L<-20^\circ \text{ C.}$

$\Delta n=0.095$

$\Delta \epsilon=-3.7$

$\eta_{20}=28.6 \text{ mPa}\cdot\text{s}$

VHR(25° C.)=98.8%

VHR(80° C.)=97.8%

EXAMPLE 26

The composition comprising the following components was prepared.

Component I	
3-H1SiB(2F,3F)-O2	10.0%
5-H1SiB(2F,3F)-O2	9.0%
3-HH1SiB(2F,3F)-O2	12.0%
5-HH1SiB(2F,3F)-O2	5.0%
3-HH1SiB(2F,3F)-O3	12.0%
Component II	
3-HHCF2OB(2F,3F)-O2	14.0%
5-HHCF2OB(2F,3F)-O2	14.0%
Component III	
3-HH-4	11.0%
3-HB-O2	13.0%

The composition had the following physical properties:

$T_c = 69.4^\circ \text{C}$.

$T_L = -20^\circ \text{C}$.

$\Delta n = 0.085$

$\Delta \epsilon = -3.4$

$\eta_{20} = 26.5 \text{ mPa}\cdot\text{s}$

$\text{VHR}(25^\circ \text{C}) = 99.0\%$

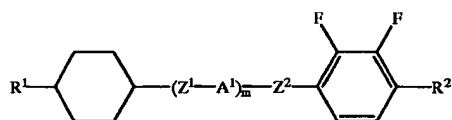
$\text{VHR}(80^\circ \text{C}) = 98.2\%$

INDUSTRIAL APPLICABILITY

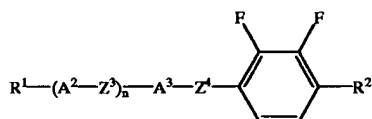
As shown in the Examples, the present invention provides a liquid crystal composition which has a suitable An in accordance with cell thickness, in particular a largely negative dielectric anisotropy, a broad nematic liquid crystal phase range, a high voltage holding ratio and a low viscosity while satisfying various properties required for liquid crystal compositions for AM-LCD.

What is claimed is:

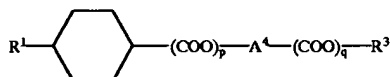
1. A liquid crystal composition comprising Component I selected from the group consisting of the compounds represented by formula (I), Component II selected from the group consisting of the compounds represented by formula (II) and Component III selected from the group consisting of the compounds represented by formulas (III-1) and (III-2)



(I)



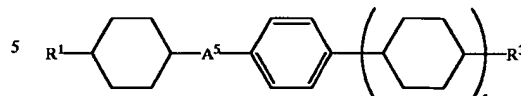
(II)



(III-1)

-continued

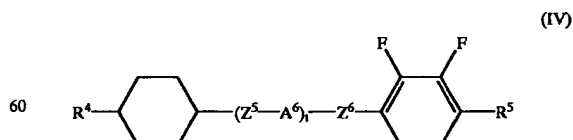
(III-2)



wherein each R^1 independently represents an alkyl group having 1–10 carbon atoms or an alkenyl group having 2–10 carbon atoms; each R^2 independently represents an alkyl or alkoxy group having 1–10 carbon atoms, or an alkenyl group having 2–10 carbon atoms; Z^1 and Z^2 represent $-\text{CH}_2\text{SiH}_2-$, a single bond or $-\text{CH}_2\text{CH}_2-$, with the proviso that one of Z^1 and Z^2 represents $-\text{CH}_2\text{SiH}_2-$ and the other represents a single bond or $-\text{CH}_2\text{CH}_2-$; ring A^1 represents a trans-1,4-cyclohexylene group, or a 1,4-phenylene group in which one or more hydrogen atoms may be substituted with fluorine atoms; m is 0 or 1, with the proviso that when m is 0, Z^2 represents $-\text{CH}_2\text{SiH}_2-$; Z^3 and Z^4 each independently represent a single bond, $-\text{CH}_2\text{CH}_2-$, $-\text{CF}_2\text{O}-$ or $-\text{OCF}_2-$; rings A^2 and A^3 represent a tetrahydropyran-2,5-diyl group, a trans-1,4-cyclohexylene group, a cyclohexa-1-ene-1,4-diyl group, or a 1,4-phenylene group in which one or more hydrogen atoms may be substituted with fluorine atoms; n is 0 or 1; with the proviso that when n=0 and Z^4 represents a single bond or $-\text{CH}_2\text{CH}_2-$, then ring A^3 represents a tetrahydropyran-2,5-diyl group; when n=0 and Z^4 represents $-\text{CF}_2\text{O}-$ or $-\text{OCF}_2-$, then ring A^3 represents a trans-1,4-cyclohexylene group or a cyclohexa-1-ene-1,4-diyl group; when n=1 and Z^3 and Z^4 each independently represent a single bond or $-\text{CH}_2\text{CH}_2-$, then one of rings A^2 and A^3 represents a tetrahydropyran-2,5-diyl group; when n=1 and Z^3 and/or Z^4 represent $-\text{CF}_2\text{O}-$ or $-\text{OCF}_2-$, then rings A^2 and A^3 represent a trans-1,4-cyclohexylene group, a cyclohexa-1-ene-1,4-diyl group, or a 1,4-phenylene group in which one or more hydrogen atoms may be substituted with fluorine atoms; each R^3 independently represents an alkyl group having 1–10 carbon atoms or an alkenyl group having 2–10 carbon atoms, in which one $-\text{CH}_2-$ may be substituted with $-\text{O}-$; ring A^4 represents a 1,4-phenylene group or a trans-1,4-cyclohexylene group; ring A^5 represents a trans-1,4-cyclohexylene group, or a 1,4-phenylene group in which one or more hydrogen atoms may be substituted with fluorine atoms; p, q and s are each independently 0 or 1 with the proviso that (p+q) is 0 or 1.

2. A liquid crystal composition as claimed in claim 1, which comprises 3–80% by weight of Component I, 3–80% by weight of Component II and 1–80% by weight of Component III.

3. A liquid crystal composition as claimed in claim 1, which further comprises Component IV selected from the group consisting of the compounds represented by formula (IV)



(IV)

wherein R^4 represents an alkyl group having 1–10 carbon atoms or an alkenyl group having 2–10 carbon atoms, R^5 represents an alkyl or alkoxy group having 1–10 carbon atoms or an alkenyl group having 2–10 carbon atoms, Z^5 and

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Z^6 each independently represent a single bond or $-\text{CH}_2\text{CH}_2-$, ring A^6 represents a 1,4-phenylene group or a trans-1,4-cyclohexylene group, and t is 0 or 1.

4. A liquid crystal composition as claimed in claim 1, wherein the clearing point (T_c) is 60 to 100° C., the

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refractive anisotropy (Δn) is 0.06 to 0.12 and the dielectric anisotropy ($\Delta\epsilon$) is -6 to -1.

5. A liquid crystal display element containing the liquid crystal composition as claimed in claim 1.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,395,353 B2
DATED : May 28, 2002
INVENTOR(S) : Motoki Yanai et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 23,

Line 28, change " η_{20} 32 26.8 mPa•s" to -- $\eta_{20} = 26.8 \text{ mPa}\cdot\text{s}$ --;

Line 47, change "3-HDOCF2B(2F,3F)-O1" to -- 3-HBOCF2B(2F,3F)-O1 --.

Column 24,

Line 7, change "2-HH1SiD(2F,3F)-O2" to -- 2-HH1SiB(2F,3F)-O2 --.

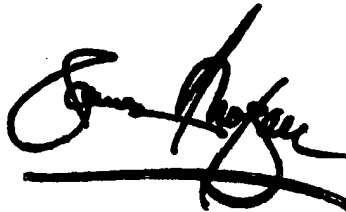
Column 29,

Line 36, change "An" to -- Δn --.

Signed and Sealed this

Fifth Day of November, 2002

Attest:

A handwritten signature in black ink, appearing to read "James E. Rogan", written over a horizontal line.

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office